NATURAL HISTORY

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FRANK E. LUTZ, EDITOR

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NATURAL HISTORY

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THE BEAUTIFUL COLORS

of butterflies are due to very minute scales, as is pointed out by Doctor Kellogg in "The Color Dust of the Butterfly" in this issue. Of the two butterflies shown here, the Monarch is red because its scales contain red pigment, but the Morpho is that beautiful blue because its scales bear excessively fine ridges that reflect the rays of light in such a way that they interfere with each other and produce a blue iridescence

NATURAL HISTORY
VOLUME XXVI MARCH–APRIL, 1926 NUMBER 2

Taking Nature Lore to the Public

BY FRANK E. LUTZ

HE is a selfish man who, knowing interesting things, does not pass on that information to his fellows. He is worse than selfish if he has acquired that knowledge through the help of his fellows and, nevertheless, imparts it to at most the favored few of them who are working along the same lines. It is clearly the duty of entomologists and it should be their pleasure to tell others about insects. Furthermore, in view of the increasing and vital connection between insects and human welfare, it is essential that the coming generation of men and women be better informed concerning their six-footed friends and enemies than our generation has been.

The American Museum's department of entomology has not been unmindful of these things and has with pleasure tried to do its duty, not alone in research, but also in education by means of exhibitions, by the printed word, by talks given to visible auditors and also broadcast by radio, and, finally, by taking the message to people out-of-doors. Some of the ways in which we have told about insects in our exhibition hall were illustrated in a recent number of NATURAL HISTORY and the present issue is an illustration of our efforts with printed words, efforts in which we have been generously assisted by willing and able colleagues. Let me tell you briefly about the other ways in which we are taking insect lore to the public.

Just a word in passing as to research, for research need not be as distinct from "taking nature lore to the public" as it usually is. Our Station for the Study of Insects is mentioned below in connection with our "Nature Trails,"

At the entrance to our grounds

but one of the main purposes for which that station was established was research. Our hope is that there we may learn more about the lives of the common insects that the public sees but does not understand—and neither do we. We are so ignorant of the intricacies of entomology that we can learn much by a study of the common things at our very doors. These are of popular interest, at least, and the knowledge we gain about them is certain to have an application in cases of less common

"Headquarters" Cabin of the Station for the Study of Insects. The automobile is the one that several years ago served as laboratory, living quarters, and means of transportation for one of the Museum's entomological field parties in Colorado

The automobile that brought cooked food from Bear Mountain Inn to our cabin at the Station for the Study of Insects

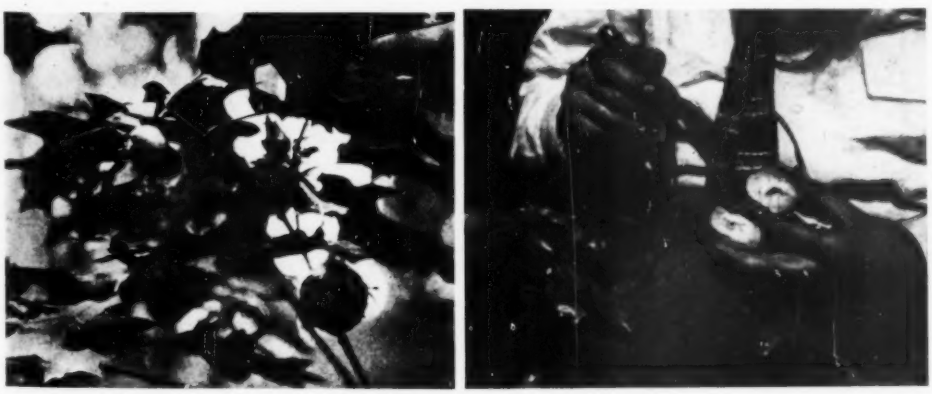
species; also what we learn about insects that are not injurious will help us with those that are. Doctor Howard has developed this same idea more fully in his article in this issue of NATURAL HISTORY and—who knows?—our station may become like that for which he pleads. At any rate, we hope that in our research there we may be practical, even though the immediate application of our work may not be apparent, and that we may be popular in the sense that we keep in mind our duty to the public.

Lecturing is older—much older—than writing as a means of imparting information; and, except for the limitation in the number of people that can be reached by one person, it is often more effective. Since, just as in books, a good picture is frequently worth pages of text and sometimes indispensable, so in lectures illustrative material, either the actual specimens or pictures or both, are exceedingly helpful. This is particularly true if, when dealing with living things, the pictures show the things as living—if they display that very common attribute of life, motion.

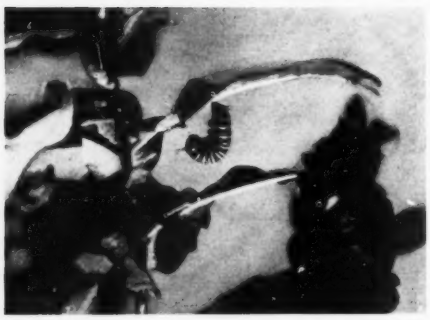
Furthermore, motion pictures with accompanying captions can be made to tell a continuous story that can be given well without the necessity of the lecturer who prepared them being present and, also, there is no limit (except cost) to the number of copies that can be made of a film and these copies can be shown throughout the world. The motion picture, then, is a means of multiplying the reaching power of a lecturer, a feature that is quite akin to that of books and magazines.

It is not easy to make motion pictures of insects because of the small size of the subjects and because many insects move very rapidly in comparison with their size. A motion-picture film is only an inch wide and, if the photograph of the insect be made only one-tenth natural size, that insect would go entirely out of the picture if it moved ten inches at right angles to the camera; it would go out of sharp focus if it moved that distance toward or away from the camera. This difficulty is increased as we attempt to make the photograph more nearly natural size (as are also other difficulties, including illumination) and a photograph of an ant, for example, one-tenth natural size is rather small.

However, these are merely difficulties to be overcome by special instruments and better technique. Mean-



Getting "inside facts" concerning an Oak-apple, a structure which a wasp forces the oak to make as a nursery for young wasps. From the film "Winning the Insect-life Merit-badge"



Stages in the life of the Monarch butterfly. From the film "Winning the Insect-life Merit-badge"

while, we can show insects that are large enough to yield satisfactory results with our present apparatus and skill. That the case is not hopeless is shown by a film that was recently prepared for a lecture to children of members of this Museum and is now being used more generally. It is entitled "Winning the Insect-life Merit-badge."

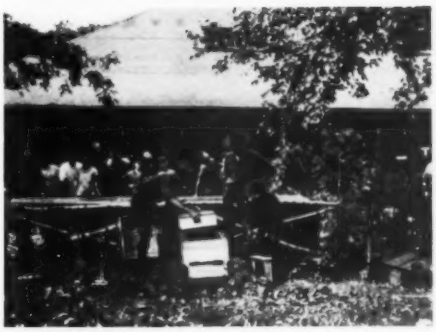
"Merit-badges" are given by scouting and other organizations to such of their members as have met given requirements in certain lines of endeavor. To win the insect-life merit-badge of the Boy Scouts, the boy must learn a great deal concerning insects and the lives that they live. This the boy did and the film shows some of his activities and some of the activities of the insects that he saw. Characteristic "shots" from this film are reproduced here; the department's association with young people who are interested in nature will be mentioned shortly.

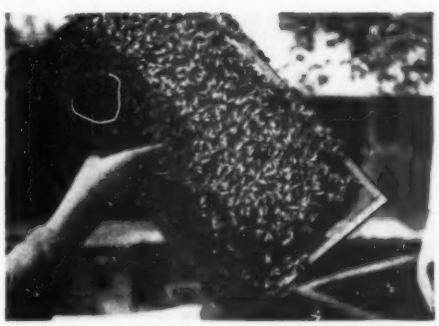
First, however, let me speak of another method of "multiplying the reaching power of a lecture," the radio. There is no good way of determining how many people hear a radio talk, since many of the more thoughtful listeners are not likely to write in about it but, when a fifteen-minute discussion of some entomological topic broadcast in this way is followed by the receipt of intelligent letters concerning it, written by people distributed from Maine to Virginia, one can be certain that many others, equally worth while, heard it but did not write. We are told that the potential audience of such a talk includes more than a million people of all ages. "Some Interesting Habits of Our Native Bees," "Insect Sounds," and "The Friendly Insects," printed in this issue of NATURAL HISTORY, are examples of radio broadcasts given by this department.

And, then, there is the matter of telling people about insects when these people are out-of-doors where they can see living specimens. I do not mean personally conducted field trips. On them one who knows can benefit at most fifteen or twenty people at one time. We label our museum exhibition halls so that visitors do not need a guide. Why not follow the same method where Nature provides the exhibits? The newspapers described our "Nature Trails" in the Harriman State Park, near Tuxedo, New York, as an "insect zoo" and that was a rather fitting name for one section of the trails. On the other hand, it told only a part of the truth, for we believe that, to understand and thoroughly appreciate the lives that insects live, you must not only see live insects but you must know about their environment, about the plants upon which they feed, and about the animals that feed upon them; you must sense the light, the shade, the moisture, and the temperature that go to make up the habitat of the insect. So, at the Station for the Study of Insects, where we made our first Nature Trails, we told our visitors about the plants, for example, and, if the visitor was interested in plants, we had something for him even though he was not interested in insects.

We told about these things partly by word-of-mouth but largely by labels and we tried to make these labels as human as every-day conversation.

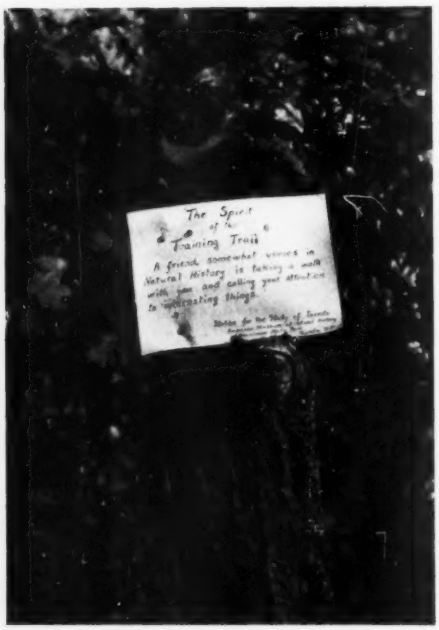
There were two Nature Trails, each about half a mile long and roughly circular. One was called the "Training Trail" and the other the "Testing Trail." Information was given on the Training Trail but on the Testing Trail there were fifty numbered questions about the plants and the insects along its sides. If a visitor wished to





With the Bees. A Boy Scout is taking his test in bee-keeping. From the film "Winning the Insect-life Merit-badge"

"test" himself, he could write his answers to these questions, bring them to us, and we would tell him his score. Also, we had competitions both between individuals and between teams.



Explaining to our visitors that the underlying idea, the "spirit," of the Trail is that "a friend is taking a walk with you and pointing out interesting things"

Instead of risking confusion by attempting to tell something about everything that grew along the Training Trail (and, for the most part, we included only those things that naturally grew there) we picked out just a few of the easy and most interesting things, especially things concerning which there is popular misinformation. Also, we largely avoided technicalities. For example, it is a technical matter to distinguish the various oaks of the black-oak group and even the specialists do not agree. So we merely said that members of the black-oak group can be recognized as belonging to that group by their having a tiny bristle at the end of each principal lobe of a leaf, while members of the white-oak group have no such bristles. We told that the acorns of the black-oak group are not palatable, while those of the white-oak group are more or less so; that many insects recognize the difference between these groups and feed only on the leaves of one or the other; and so on.

We tried to teach some underlying principles of conservation by showing that, if a flower is picked, the plant's children (its seeds) are killed; that, given a chance, a small tree would grow to become a large one; and that plants, the chestnut for example, suffer from diseases just as we do. (American chestnuts have been killed by a fungus disease and not by insects.) We asked people to benefit themselves and others by not needlessly stepping on or breaking a living plant. This they did in a mighty fine way and, as a result, although thousands tramped our Training Trail, it is at no place where it really was a trail (and not a road) more than eighteen inches wide. Only a few not-yet-knowing people—possibly hopelessly ignorant or selfish—picked the flowers that others wished to see or dropped paper where it would mar the beauty of God's out-of-doors, which it is our right to enjoy unspoiled.

The underlying idea of our labels, the "spirit of the Training Trail," was that "a friend is taking a walk with you and pointing out interesting things." This friend, the label we put there, when showing the winding tunnel inside a leaf where a tiny caterpillar spent its life feeding and growing, quoted Lowell:

> There's never a blade nor leaf too mean
> To be some happy creature's palace.

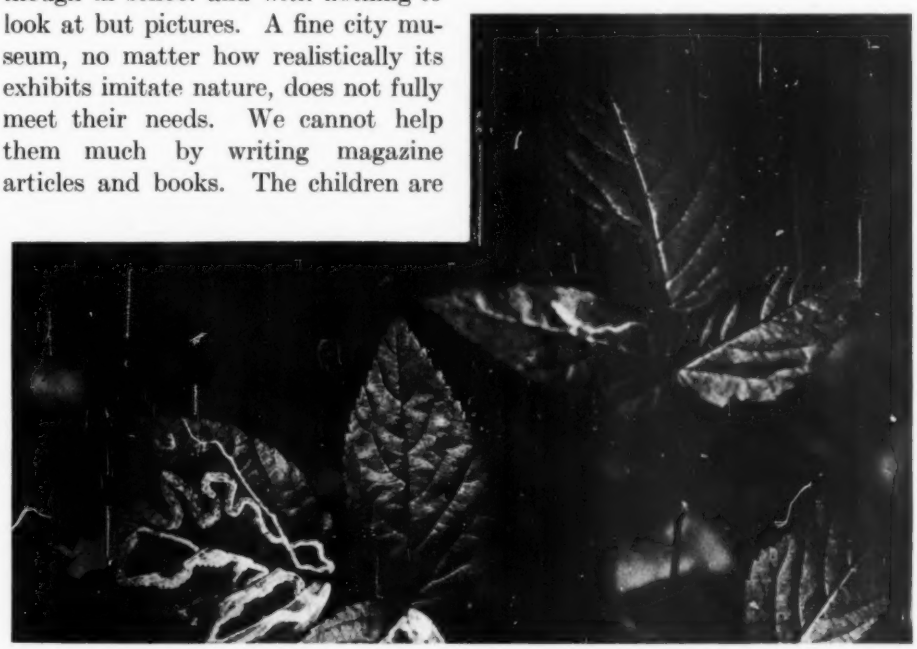
and, as the visitor walked by the side of the babbling Wild Cat Brook, one of

these friendly labels reminded of Stevenson's

"There's no music like a little river's. It plays the same tune (and that's the favourite) over and over again, and yet does not weary of it like men fiddlers. It takes the mind out of doors; and though we should be grateful for good houses, there is, after all, no house like God's out-of-doors. And lastly, sir, it quiets a man down like saying his prayers."

We put these Trails where we did, so that they might be convenient of access to the automobiling public but especially that they would be relatively near the many organization (scouting, charity, and industrial) camps in the Interstate Park. Do you realize that thousands of children from cities and towns are camped there, each for a week or more, every summer? It is not enough to lecture about nature to these children during the winter seated as though in school and with nothing to look at but pictures. A fine city museum, no matter how realistically its exhibits imitate nature, does not fully meet their needs. We cannot help them much by writing magazine articles and books. The children are in the Park every summer with nature all about them. It is the time and the place to tell them what they are keen to know.

The better of these camps have "nature councillors" and exceedingly useful camp museums, the latter preferably made by the children themselves. The Nature Trail is an additional help. Some have called it an "outdoor museum" but it is not that, for a museum is a place to which specimens are brought and in which they are stored. The nature-trail idea is to leave things where they are but to label them with interesting facts. If interesting facts are given first, less interesting ones will then be more readily grasped. Is that not true in your own case? After you have learned that a toad catches insects for food, that its young are tadpoles living in water, and that, though warty itself, it does not give warts to people who



The winding tunnel in a leaf that was "some happy creature's palace"

The official staff of assistants in the 1925 Nature Trail work

A team of East-side New York boys that took part in a contest on the Museum's Testing Trail. The little fellow in the center made high score

The bridge that carried the Museum's Nature Trail across Wild Cat Brook. It was built for us by Boy Scouts

Household insects are not out-of-door creatures and, so, on the Museum's Nature Trail they were shown in a tent

ALONG OUR NATURE TRAIL

INSECTS AND OTHER ANIMALS ALONG THE TRAIL

Aquatic insects in glass dishes, small creatures that live on the ground in moist places were caged in plaster boxes

The "insect orchestra," composed of crickets and the like. Models of a cricket's musical instrument were in the tin box

Watching the earwigs along the Trail

touch it, you will probably care to know that the scientific name of toads is *Bufo*, that the species you are looking at is *Bufo am ricana* and that it differs from another native toad, *Bufo fowleri*, in such and such characters. At any rate, on our Training Trail the labeling was not a catalogue of species but a personal conversation.

If there is but one Nature Trail in a large region, something is gained, since it is possible for people to come from a distance to see it; but that is not "taking nature lore to the public"; it is asking people to come to nature lore. So, it was extremely gratifying to see with what enthusiasm various camps took up the idea and made Nature Trails of their own. The children, in doing this work, learned more than they could possibly do by merely studying a trail that some one

A group of boys at the ants' feeding box in a tree

else had made. Furthermore, they had a sense of proprietorship; that trail was theirs; they had become part owners of nature and their fathers and mothers and all their relatives and all their other friends were welcome to come and share in the joy of knowing about out-of-doors. Thus our half-mile of Training Trail grew in a season to more than ten miles and this fact, even more than the kind verbal comments of our visitors, made us think that our work was worth while.

During the winter the Manhattan Girl Scouts made a Nature Trail on the Palisades and New York school teachers made one in the N. Y. Botanical Gardens. Others are planned throughout the country literally from the Atlantic to the Pacific. Why not? Why should there not be written or printed "friends" in every city, state, and national park telling people something concerning the things there—not just the names of them but something that appeals? Why should not the camping grounds of automobile tourists be made more than mere overnight stopping places? If a commercial concern thinks it is worth while to put its slogan where you cannot help but see it while you eat your wayside lunch, why is it not the duty of those who know about nature to meet you there and by neat, chatty labels tell you something worth while? That would be taking nature lore to you and to others of that vast company of people we call "the public," and it would be well worth while.[1]

[1]The American Museum of Natural History has issued a pamphlet telling in some detail about our Nature Trails and making suggestions concerning this work. It is available to anyone who is interested in starting such a Trail.

Interesting things along the American Museum's Nature Trail near Tuxedo, N. Y., in the Harriman Section of the Palisades Interstate Park

A Great Economic Waste

WHAT WE ARE DOING AND WHAT WE MUST DO IF WE WOULD CHECK THE RAVAGES OF INSECTS

By L. O. HOWARD

Chief of Bureau of Entomology, U. S. Department of Agriculture

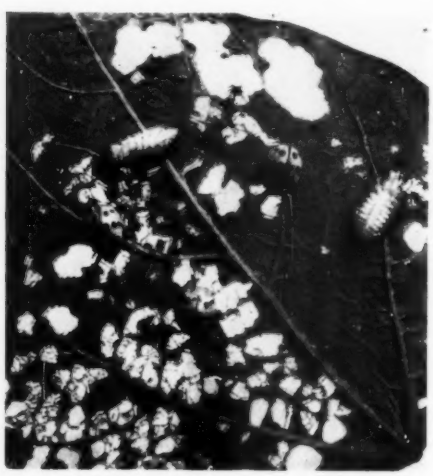
THIS exceedingly important topic is treated here by a man than whom no one can speak withg reater authority. For years Doctor Howard has been chief of the Bureau of Entomology of the U. S. Department of Agriculture and under his direction that bureau has assumed and maintained the front rank in our battle against our enemies among the insects.—THE EDITOR.

TIME was when the study of entomology was considered a trivial pursuit. Most of the people who took it up were collectors purely and simply. Descriptions of species which

A bean plant seriously injured by Mexican Bean Beetles that fed on its leaves

carried and established names were needed so that specimens might be labeled and catalogues prepared. While the pure collector's spirit—the spirit which reaches out after rare species to fill gaps—animated most of these men, there were others deeply interested in the strange lives of many species, in the infinite diversity of life-methods that exist among them, indicating to the minds of some, like dear old William Kirby, Rector of Barham, for example, "the glory, power, and wisdom of the Almighty."

But the opinion of people in general on the subject of insects, and their opinion of the men who study them, have changed greatly these later years. It has become strikingly obvious that insects are collectively the most important enemies and rivals of humanity on earth. It has become perfectly plain that if human beings are to maintain their hold on this globe, if they are to continue to exist, they must learn to

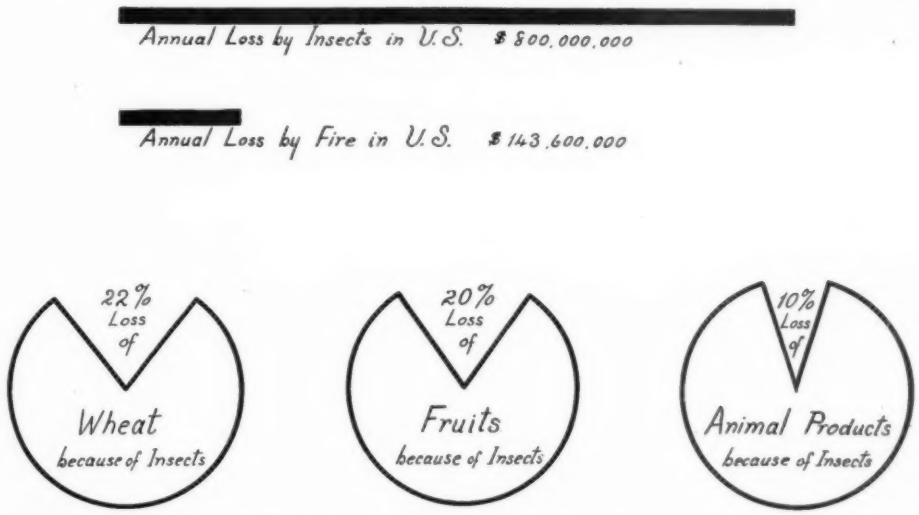


Larvæ and adults of the Mexican Bean Beetle, an injurious relative of the beneficial Lady Beetles. It is now seriously abundant in parts of the United States

control insects. So the entomologist has risen in our esteem. In him and the results of his work lie our hopes for the future comfort, happiness, and prosperity, and even the very existence of mankind.

Then, too, the entomologists themselves have changed. A new type has arisen among them. He is termed the *economic entomologist*, and he is devoting his life to the study of insects for the purpose of finding means of controlling their multiplication and spread and thus limiting or doing away with the enormous damage they are bringing about.

It is probably unnecessary to dwell at length upon this damage, but something about it must be said here. It has been estimated that the money loss from the work of insects in the United States exceeds two billions of dollars yearly. To put it in other words, *insects in this country nullify the expended labor of a million men.* They destroy, in their feeding, from one-tenth to one-fifth of all the crops planted. They carry and spread plant diseases which destroy an additional percentage of some of our crops. They damage stored food and other stored products. They transmit certain diseases of man, reducing his economic efficiency to the extent of hundreds of millions of dollars annually. They lessen the value of his cattle and of his other domestic animals by direct parasitism or by the carriage of disease; and in many other ways they are destructive to his interests.


Annual Loss by Insects in U.S. $800,000,000
Annual Loss by Fire in U.S. $143,600,000
22% Loss of Wheat because of Insects
20% Loss of Fruits because of Insects
10% Loss of Animal Products because of Insects

Diagrams indicating the great economic waste caused by a few injurious kinds of insects. The figures are, of course, based on estimates and they vary from year to year

Governments have begun to realize all this, and government services of trained men working on the many problems involved are springing up in all civilized countries. The United States and Great Britain with its numerous dominions and colonies have been the leaders, but France, Italy, Germany, Japan, and many other countries are also active in this way. The appropriations made by governments in support of the work have been growing rapidly, especially since 1900, and for the fiscal year ending June 30,

A mass of Japanese Beetles feeding on apples. Damage done to the leaves can also be seen here. This species (*Popillia japonica*) is related to our May Beetles and was first seen in this country ten years ago near Philadelphia, probably having been brought from Japan as eggs or young in the soil about the roots of shrubs

1926, our own Congress has given the Bureau of Entomology of the Department of Agriculture $2,500,000 to be expended in the study of insects in the effort to control crop pests.

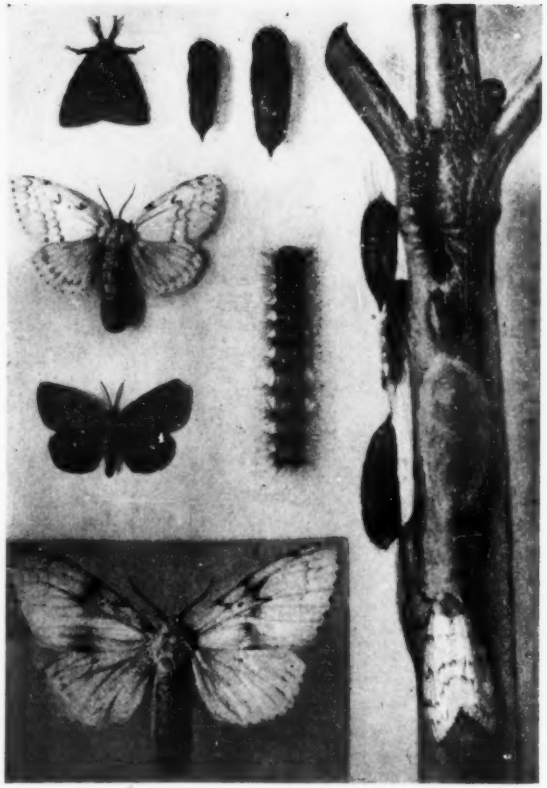
This is a very large sum, and would seem to the average man amply sufficient to finance all sorts of research. And it is true that with its aid an enormous amount of useful work is being done, and that during late years many successful means of control have been elaborated, demonstrated on a large scale, and given to the public.

But at the same time these large appropriations have been budgeted strictly. A large part of the money has been called forth by great emergencies, like the invasion of the cotton belt by the Boll Weevil; like the threatened disastrous spread of the Gipsy Moth, of the European Corn-borer, of the Japanese Beetle. In these cases and many others of scarcely less importance, such as the Mexican bean beetle, the alfalfa weevil, and the peach moth, the need for speedy relief has been very great and all possible efforts have been made to prevent spread and to find the quickest and cheapest way to kill enough of the pests to allow the agricultural industries involved to continue with profit.

An enlarged picture of a Japanese Beetle It is naturally about half an inch long

A golf course at Riverton, New Jersey, near the center of the Japanese Beetle infection. The young of this insect live underground, feeding on the roots of grasses to such an extent that the sod can be "rolled up like a carpet"

Sod pulled aside, disclosing the young of the Japanese Beetle feeding at its roots



THE GYPSY MOTH

This species (*Porthetria dispar*) was introduced from Europe about 1868. Larvæ, pupæ, and adu[illegible]wn at the left, the male being smaller and much darker than the female. The middle picture shows a mass of larvæ trying to climb up a tree trunk b[illegible]ed by a band of sticky material. Of the trees on the right, those with leaves were protected by such bands; the others were not so protected and Gypsy Moth larvæ defoliated them

ORIENTAL FRUIT MOTH

This was discovered in the District of Columbia about 1913 and described as a new species, *Laspeyresia molesta*. It probably reached there from Asia in a shipment of Japanese flowering cherries, for it bores in the twigs of these trees. It also attacks plums and, as is shown on this page, peaches. It is related to the very destructive Codling Moth, an immigrant from Europe

This is all perfectly natural; it is all just as it should be, except that it is being impressed upon us more and more that we are not able to do other than superficial work upon the basic aspects of insect life. It is obvious that if we are to continue to support our increasing millions, we must eliminate waste. *And it is obvious that the greatest of all wastes is the appalling amount of labor and money that we use literally in feeding insects.* It is equally obvious that insects are our worst rivals and enemies, and that they are apparently better fitted for existence on the earth than are human beings. Therefore, successfully to fight them, we must know absolutely all about them.

Corn injured by the European Corn-borer (*Pyrausta nubilis*), introduced into this country about fifteen years ago and now found in Canada and much of northeastern United States

Confronted with such a fight, it is pitiful how little we know about our worst enemies. We can catch them in traps; we know that we can poison

them with certain chemicals; we know that in some cases we can vary our methods of cultivating crops so as to lessen insect damage; we know that in certain instances we can utilize the services of the insect enemies of injurious forms, and other things we have found out that we can successfully use.

But the vastly greater part of the work of the economic entomologist has not been basic, and it cannot be basic under present conditions. No government has ever made appropriations for basic studies, and such studies as are being conducted in the university laboratories and in the museums are being carried on in a more or less desultory way and the workers are necessarily isolated. The work of the economic entomologists who are employed by the general governments and by the different states has consisted, and must consist, largely of efforts to apply known facts to special problems. The emergencies confronting these men have been so great that they have had no time to conduct the long investigations that might give them other weapons than those nearest at hand. Their fight has been so strenuous that in a way they have lost their perspective.

It is true that they have done magnificent work. They have confronted many difficult situations with success notwithstanding their simple weapons. But the great basic principles which have brought about the conditions that they have been called upon to meet have not been considered by them in their haste for immediate relief measures. Their knowledge of the forms they are trying to fight is hardly more than superficial when we stop to realize what should really be known.

There is a crying need for funds adequately to endow prolonged and profound studies of many questions relating to insects. These creatures differ radically in most ways from any form of life of which we have anything like intimate knowledge. We have no definite information, for example, as to such simple things as the sight, the hearing, the senses of smell and of taste; we have no definite knowledge of what it is about certain plants or certain types of food that attracts insects; we know practically nothing about the problem of nutrition in the case of insects; we know almost nothing about the diseases of insects; neither have we any competent knowledge of the intricate phases of parasitism, nor of the exact effects of temperature or moisture. Neither are we able with absolute certainty to place all insects in their proper groupings and to know exactly the relationships that exist among them; and there are very many forms which as yet have not been described and named. This description and naming, this establishing of the relationships among the different forms, enabling the identification of a given species among its innumerable relatives, may seem unprofitable labor, but it is as essential as the machinery for the identification of the human

The European Corn-borer: larva, pupa, male, and female

Larvæ of the Cotton-boll Weevil feeding inside of a boll which they have destroyed

malefactor in the criminal courts at law; and the taxonomic tables worked out by the close students are as useful and as important as the fingerprint records in such courts.

The elaborate studies that have been made of all of the physiological reactions of the human species and other warm-blooded animals must be made also of the insects if we are to begin to know them as they should be known and if we are ever to control them. How can such vitally necessary work be done?

One cannot blame a busy Congress, harassed by the insistent urge of the country's crying needs, absorbed in its efforts to respond to the most urgent, the most immediate of these needs, without compromising the financial position of the public treasury, if it fails to do more than try to meet situations as they exist at the present moment. There is no present hope, then, from government.

But there should be a permanent foundation for the study of the fundamentals of insect life, administered by the Smithsonian Institution possibly, or possibly in some other way. Such a foundation should organize a large group of the best-trained men, who should be charged with the careful study of every phase of insect life from the chromosome to the last reaction of the adult throughout the enormous range of variation that exists in this now almost mysterious insect complex.

From the work of such a group of men would come ultimately a wealth of knowledge that would enable civilized man to fight his worst enemies, *not half blindly as now, but with a perfect understanding of everything about them.*

An enlarged photograph of the Cotton-boll Weevil, a Mexican insect that has invaded southern United States

With such knowledge, the control of insects may possibly prove to be a comparatively simple thing. Without it, we are working more or less in the dark.

The Parima River near the terminus of the Rice Expedition. Photograph by Hamilton Rice

Insects and Man in Tropical America

IMPRESSIONS FORMED ON A JOURNEY TO THE RIVER AMAZON AS ENTOMOLOGIST OF THE THIRD HAMILTON RICE EXPEDITION

By J. BEQUAERT
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THEODORE ROOSEVELT said, on his return from South America, that the most dangerous animals he met were insects. Doctor Bequaert is an international authority on these foes of man's health and vividly describes them here. However, as he shows, the case is far from hopeless and we may look forward to the day when "jungle peril" will be a thing of the past.
—THE EDITOR.

DURING the summer of 1924, I was given the welcome opportunity of visiting the River Amazon, a region of unusual fascination to the naturalist. The party to which I was attached as entomologist was organized by the department of tropical medicine of the Harvard University Medical School, under the leadership of Dr. R. P. Strong. It was itself the medical branch of the Third Hamilton Rice Expedition to South America. It is characteristic of the rapid growth of medical entomology that nowadays no medical expedition to the tropics deems it feasible to dispense with the services of an entomologist. A brief narrative of my experiences in South America will, perhaps better than an academic disquisition, make it clear why so much importance is attached at present to the investigation of insects in their relation to health.

The main purpose of Doctor Rice's expedition was a geographical survey of the Uraricuera and Parima rivers, which form the western headwaters of the Rio Branco, on the borderland between Venezuela and Brazil. This objective was successfully reached by Doctor Rice in the early part of 1925, though not without much hardship and danger. Lack of time, however, prevented most of the medical party, including myself, from traveling beyond Caracaray, a small Brazilian settlement at the head of steam navigation on the Rio Branco.

On the evening of June 25, I sailed from New York on a steamer of the Booth Line, and early in the morning of July 11 sighted the coast of Brazil,

at the mouth of the Pará River, where I joined the rest of the party. A modern liner on the high seas is probably the last spot an entomologist would choose as a promising field for research. Yet a little investigation of forecastle, hold, or pantry discloses the presence of many insects that either have elected the vessel as a permanent abode or travel as stowaways, having gained access accidentally in merchandise or supplies. I do not refer here to any of the few insects of unsavory reputation that insist upon claiming man as their closest friend. I wish rather to call attention to a multitude of stragglers of more independent habits: beetles whose grubs live in foodstuffs, in timber, or in raw materials; roaches that pilfer the provisions; ants that nest in hidden corners and make steady raids upon the pantry; flies that bite animals and man or whose maggots thrive in refuse; parasitic wasps that merely prey upon their neighbors; and many others. This assemblage of insects, highly artificial to be sure, nevertheless is unique in that its members are all domestic, having adapted their habits to those of man. They form a true entomological underworld, with all the cunning and endless ramifications the word implies.

Ever since the early Egyptians and Phœnicians raised shipbuilding and navigation to an art, insects of many kinds have traveled back and forth between the continents. The opening up of the route to India and the discovery of the Americas gave a tremendous impulse to these exchanges, which became still more frequent after steam navigation and railroads practically annihilated distances. Some insects have now become such thorough cosmopolites that their original home is as difficult to trace as the ancestry of the American Indian. The whole subject is of much interest to the biologist: it not only gives a clue to the present world-wide range of certain insects, but incidentally throws much light upon the problem of migration and upon the various ways in which animals become adapted to a new environment.

Moreover, insect tramps are of foremost importance to the sanitarian, since they are so often instrumental in the spread of epidemics. It is no longer necessary to dwell upon the transmission of plague by rat fleas and the rôle ships play in carrying this dreadful scourge into healthy territory. Perhaps it is not so clearly realized that the yellow-fever mosquito (*Aëdes ægypti*, or *Stegomyia fasciata*, as it is more commonly known by medical men) and the disease which it transmits owed their wide extension in tropical and subtropical regions to transportation by ships. From the fifteenth century to the present day yellow fever was one of the diseases most frequently afflicting those traveling by ship, so much so that it was familiarly known as "ship's fever" or "yellow jack." Everybody who has visited tropical harbors knows from experience that mosquitoes readily enter ships that are at a wharf or alongside lighters that come from the shore. But, while most of the species disappear soon after the vessel leaves port, living *Aëdes ægypti* may be carried great distances. Repeatedly they have been found alive in temperate harbors even on modern steamers coming from mosquito coasts. In the old days of sailing-ships, the damp, dark, and stuffy living quarters offered almost ideal conditions for the adult yellow-fever gnat. In addition,

it could breed freely during the voyage in the storage tanks and casks, or in the rain collected in a sail, which were then the only sources of drinking water. Indeed, the transmission of yellow fever from port to port was clearly recognized long before the rôle of the mosquito became known. The slave ships were looked upon with particular suspicion and one well-meaning writer even stated that yellow fever was the price Europe paid for the slave trade. There can be little doubt that the yellow-fever mosquito was carried by ship from West Africa, probably its original home, to the Americas, where it is now found in the tropical and subtropical parts; along the Amazon and its affluents it has extended as far as steam navigation reaches. Since, once infected with yellow fever, *Aëdes ægypti* may transmit it to man for at least from fifty to sixty days thereafter, the rapid spread of the disease over a large territory is easily understood.

After a long ocean journey the approach to a new tropical coast has for the naturalist a charm of its own, compounded of a peculiar mixture of glad excitement over having reached a promised goal and of subdued anxiety before the mysteries of the unknown. Many subtle influences seemingly conspire to render it an experience not to be forgotten. My first acquaintance with Brazil was no exception to the rule. For some hours before we descried the coast, turbid waters, unwilling to lose their identity in the brine of the ocean, had heralded the river of the legendary Amazons. A soft, strangely scented land breeze greeted us long before the low shores began to show as dim specks at the horizon. With dawn we found ourselves entering the broad estuary of the Pará River and soon the first messengers from the tropical land came aboard: large hawk moths and elegant butterflies gracefully fluttered over the decks, and swift dragon flies rested for a while in the riggings. As the ship closed in on the shore, insect life became more obtrusive: soon the first horseflies were netted, while a good-sized, black *Ammophila* wasp caused some commotion by stinging one of the lady passengers without the slightest provocation. Thus, in various ways Nature warned us that we were about to enter the domain not of man but of the insect.

Soon the white towers of the cathedral of Belem do Pará (as the city of Pará should properly be called) appeared above an agglomeration of low houses. We passed an old, circular fort of red bricks, built upon a rock in midstream, and entered port. Eventually, after the tedious formalities of debarking, we were installed at a comfortable hotel. Here none of the windows were screened and no mosquito bars were provided in the rooms. We were confidently told that mosquitoes were unknown and, as a matter of fact, owing to the drought prevailing at the time, very few of them were in evidence. We devoted the next few days to the fauna and flora of the vicinity. Although we found much to interest us, the locality is no longer the naturalist's paradise described in such glowing terms by H. W. Bates. The reason is not far to seek. At Bates's time Pará had a population of less than 20,000 inhabitants, while today it has more than 200,000 and extends over a large area. On our very first walk we became acquainted with that minute, but extremely troublesome pest of the American tropics known as the red-bug or harvest mite, commonly called "chigger" in the

United States and "*mucuim*" in Brazil. These mites are the larval stages of certain species of *Trombicula*, the adults of which are much larger, velvety red, predaceous creatures. The red-bugs themselves are extremely minute, generally bright red, spider-like, six-legged creatures, just barely visible to the naked eye. They often occur in abundance on low vegetation, particularly in pastures, in certain cultivated fields, and in waste places covered with rank weeds. Here they await a chance to reach the body of some animal on which they suck blood for a time. When they find their way to man, they attack the skin, causing intolerable itching, followed by papules surrounded by red or violaceous spots. In certain persons who are particularly sensitive, the effects may be extremely serious. There is no evidence that the American red-bugs carry a specific disease, but a species in Japan, *Trombicula akamushi*, transmits the *tsutsugamushi*, or Japanese flood river fever, from a rodent to man.

Our stay at Pará was all too brief. Late in the evening of July 19 we embarked on a steamer of the Lloyd Brazileiro for Manáos. The next morning found us traveling through the *Furo*, or Narrows, of Breves, a series of winding channels, two hundred to three hundred fifty yards wide, which connect the estuary of the Pará and Tocantins with that of the Amazon. The low, muddy banks, periodically flooded by the tide, are densely covered with a maze of luxuriant vegetation, where the crude huts of the *caboclos*, or half-Indians, nestle between the delicate fronds of elegant *assahy* palms (*Euterpe*). The whole region is, however, very unhealthful and a hotbed of malarial fever, so that we were glad to leave it before sunset and to enter the southern branch of the Amazon delta.

For the next three days we feasted our eyes upon the glorious scenery of the mightiest river of the world and, in the cool, breezy evenings, enjoyed the magic of the brief tropical twilight. This monarch of rivers is so wide and deep and carries such a huge volume of water that, were it not for the speedy current, one might easily mistake it for an inland sea—the *Rio Mar* of the Portuguese. Although innumerable low, marshy islands generally obstruct the view of the main banks, there are many stretches of open water eight miles or more in width, where both shores are barely visible at the same time. When the ship followed the banks, we could study the vegetation at leisure. The immensity of the Amazonian forest is proverbial and somewhat appalling to the newcomer. Its dangers, imaginary and real,—the worst of which is perhaps famine—seem to produce a kind of mental paralysis upon the mind of the average explorer, who all too readily describes it, with Alberto Rangel, as a "green Inferno." Throughout the lowlands of Amazonia the vegetation is generally a rain forest perennially green. The most striking points of difference from temperate woods are the huge dimensions of many of the trees; the unchecked growth, most of the plants being evergreens and very few of the trees ever shedding all the leaves at once; the endless variety of the flora; the abundance of creepers, or lianas, and of epiphytes, or air plants; the predominance of certain strange trees, such as palms; and finally the almost total absence of grasses. In Amazonia, however, as elsewhere in the tropics, there are three quite distinct types of forest, each with its own inter-

est for the naturalist and with its peculiar problems for the sanitarian.

Second growth, or secondary forest, is the type which the newcomer to Amazonia is most apt to meet first, and it unfortunately is the poorest of the three. It is found in the neighborhood of all towns and villages, where at one time or another the primeval forest was cleared away by man to make place for crops or to furnish firewood or timber. When such areas are permitted to return to the wild state, they are not at once reclaimed by the original virgin forest, but they rapidly develop a peculiar, artificial plant growth, where the trees are much less varied than in primary rain forest, never reaching large dimensions, while the undergrowth tends to become an impenetrable jungle. In Brazil such second-growth woods are usually marked by dense groves of trumpet trees or *imbaubas* (*Cecropia*), which shelter stinging ants in their hollow trunks. Favorable breeding places in profusion are here provided for hosts of mosquitoes, especially for malaria-carrying anophelines, in the stagnant, grass-grown rain puddles, in the swampy glades, in holes of decaying tree stumps, and similar places. During the day the insects hide in the dense weeds and in the evening migrate to the near-by human settlements. The "jungle" at the outskirts of towns is perhaps the most troublesome problem confronting anyone attempting to control the mosquito pest in the tropics. Too often the expense involved in eliminating all breeding places in the surrounding second growth is out of all proportion to the size of the town.

As one travels along tropical rivers, one has many opportunities of studying another type of rain forest, known to botanists as inundated forest. It covers all those stretches of alluvial, low country that are periodically flooded by the rising rivers or by the rains and that remain under water for weeks or months. In Amazonia such flooded forests generally go by the name of *igapó* or *gapó*, while the alluvial areas which they cover are called *varzeas*. The water-logged condition of the soil excludes most of the trees that grow in primary rain forest on high, dry ground. On the whole, the vegetation does not reach any considerable height; but, on the other hand, it grows quite close, and the numerous intertwining lianas and spiny creepers transform such growth into an almost impenetrable thicket. The unusual extent of *igapó* forest is one of the most striking peculiarities of the Amazon Basin. At the season of highest water, when the Amazon rises fifteen to forty feet above its lowest level, the whole alluvial valley forms, as it were, a major bed to the river, some fifteen to thirty miles wide, where the current flows swiftly between the very trunks of the trees. It is then possible for canoes to travel through the forest and pass across-country from one affluent to another. When the flood slowly subsides, it leaves behind many pools and even small lakes partly choked with floating plants. The stagnant water as well as the muddy shores form ideal breeding grounds for hordes of biting insects. Here originate myriads of winged pests that assail the traveler on the rivers or the venturesome camper on the shores: mosquitoes, or *carapanas*, some of which (*Psorophora*) bite during the day and are replaced at night by other kinds (*Mansonia*); sand flies, or *muruim*, particularly objectionable on account of their minute size, which facilitates their attacks, and their persistence at dusk and dawn; and

horseflies, or *mutucas*, of many species. Even the most fastidious tourist, who merely gathers his impressions of Amazonia from a comfortable deck chair, does not fail to make the acquaintance of the little *mutuca* known as *cabo verde* (*Lepiselaga crassipes*). This pernicious insect is probably responsible for more bad language than any other of the multifarious pests of tropical America. It is about the size of a house fly, black with clear wing-tips, a sprinkling of bright green scales over head and thorax, and eyes curiously checkered in zigzag fashion with green, blackish purple, and bright violet blue. Its flight is so silent and it settles so cautiously that it generally takes its victim unawares. It always reminded me in this respect of the much-dreaded tsetse fly of African rivers. Sometimes the bite is hardly perceptible, but generally it feels like a sharp prick of a pin. The ; en spot swells to a large wheal and produces intense itching, which may last for a long time. Often a drop of blood trickles from the gash made in the skin by the sharp proboscis. It is fortunate that this fly does not carry the germ of any disease, at least so far as we know at present.

I regret to say that I cannot give a first-hand description of the third and most interesting type of Amazonian forest, namely, the virgin or primary rain forest of the upland, or what the Brazilians call *terra firma*. I had no occasion in Brazil to visit any point away from the rivers, where the forest had not been spoiled at one time or other by the destructive activity of man. From accounts by creditable and experienced observers, such as Ule and Le Cointe, I judge, however, that the characteristics of primeval Amazonian woods are not very different from those of tropical African forests, which I visited some years ago. The immense trees, like huge pillars of a lofty cathedral, rise from a hundred to a hundred fifty feet in height and support a dense canopy of foliage, through which the fierce rays of the tropical sun are filtered into myriad beams of subdued light. The undergrowth of small trees and bushes is rather scattered; and, as the floor of the forest bears but few and low herbaceous plants, it is not so very difficult to walk between the trees. The only serious obstacles that impede one's progress are the many fallen trees and partly decayed stumps. Moreover, if one dares to stray away from the beaten path, one is soon hopelessly lost in the seemingly uniform maze, unless one has acquired through long experience the Indian's astute sense of direction. An overawing silence generally reigns, and one meets but rarely with wild animals or even with birds. These higher forests are the most healthful part of the country and relatively free from insect pests. They harbor, however, the small *tatukira* midge (*Phlebotomus*), which infects man with the germs of cutaneous leishmaniasis, a grave skin-disease of the South American forests.

In spite of its many discomforts and dangers, there is much of real beauty in the equatorial forest. To me it is a source of perennial surprise that poets have so seldom been inspired by the glory of the tropics. The splendor of the "grandiose equatorial vegetation, as it sprouts from a soil drenched with storms and unfolds its evergreen foliage in the scorching light," would, it seems, suffice to fire the imagination. Let us hope that some future Byron will do it justice! Perhaps the very complexity of equatorial nature baffles the mind and hinders the flight of Pegasus, for

nowhere is Goethe's saying more true that "one sees only what one knows."

That part of the river known as the Lower Amazon extends from the estuary to the confluence of the Rio Negro. It is a stretch some 1,100 miles long, navigable at all times for sea-going vessels. Thus the very center of Amazonia is placed in direct connection with all the ports of the world. The focus of Amazonian trade is Manáos, situated three degrees south of the equator, on the left bank of the Rio Negro, about six miles from the main Amazon. Although founded in 1669, it was still a small town of 5,000 inhabitants or less at the time Wallace and Bates visited it. Owing to the growth of the rubber trade, it has become during the last thirty years a city of considerable importance, and in 1914 the population was estimated as between 60,000 and 70,000. At present it is struggling through a period of decline, but its central location in one of the richest natural regions of the world vouchsafes its future prosperity. It is a typical tropical city, with many of the unsanitary conditions and not a few of the discomforts which one expects of such places. It is only fair to add that, through the efforts of some far-seeing citizens, there is promise of improvement even in matters of hygiene. Here as elsewhere, even in more enlightened communities, the chief struggle is against the apathy and ignorance of the mass of the population, who seemingly attach more importance to political squabbles than to the care of health.

A pool at Manáos that is well suited to the needs of mosquitoes. Photograph by Ralph Wheeler

I was not disappointed in my expectation of finding at Manáos much of interest in the entomological line, even though the original vegetation has been wantonly destroyed for many miles around the town. The region appears to offer an environment particularly favorable to mosquito life, for no less than thirty-two species of these insects are already known from the town and its immediate vicinity. Perhaps the most common of them is the yellow-fever mosquito (*Aëdes ægypti*), which I

On an upper branch of the Rio Branco. Black flies breed here in countless numbers, their larvæ clinging to the stones in the swift rapids. Photograph by Hamilton Rice

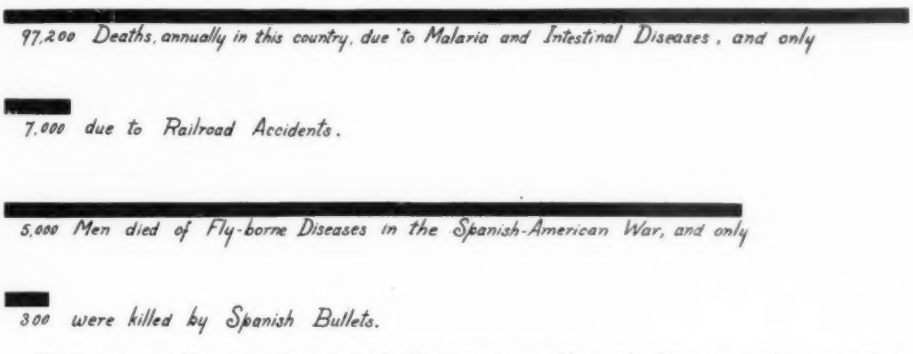
found breeding in most of the freely exposed receptacles containing pure water, especially in tanks of drinking water. The five-banded mosquito (*Culex quinquefasciatus*) preferred dirtier water, but was hardly less abundant. Adult malaria mosquitoes, or anophelines, were rare, their development seemingly checked by the drought; but I found their larvæ in large numbers floating between the water plants that choke the creeks, or *igarapés*, dividing the various sections of the town. These creeks also harbored the remarkable larvæ of *Mansonia*, which, unlike those of most other mosquitoes, do not come to the surface to breathe, but attach themselves to the roots of floating vegetation, especially of water lettuce (*Pistia stratiotes*), cutting the bark of the root with their sharp air-tubes. The adults of most Mansoniæ are severe biters and those of *Mansonia titillans* fly considerable distances, often entering houses of Manáos

During the short trip on the lower Rio Negro and Rio Branco, we became acquainted with several insect pests not encountered before. One of these, which no member of the party is likely to forget, was the minute black fly locally known as *piúm* (*Simulium amazonicum*). It torments the traveler all day long, but especially in the morning and before dusk. H. W. Bates's account of its activities can hardly be improved upon:

> We made acquaintance on this coast (viz. the southern shore of the Amazon, near the mouth of the Rio Negro) with a new insect pest, the *piúm*, a minute fly, two-thirds of a line in length, which here commences its reign, and continues henceforward as a terrible scourge along the upper river, or Solimoens,

to the end of the navigation on the Amazons. It comes forth only by day, relieving the mosquito at sunrise with the greatest punctuality, and occurs only near the muddy shores of the stream, not one ever being found in the shade of the forest. In places where it is abundant, it accompanies canoes in such dense swarms as to resemble thin clouds of smoke. It made its appearance in this way the first day after we crossed the river. Before I was aware of the presence of flies, I felt a slight itching on my neck, wrist, and ankles, and on looking for the cause saw a number of tiny objects having a disgusting resemblance to lice, adhering to the skin. This was my introduction to the much-talked-of *piûm*. On close examination they are seen to be minute two-winged insects, with dark-colored body and pale legs and wings, the latter closed lengthwise over the back. They alight imperceptibly, and squatting close, fall at once to work, stretching forward their long front legs, which are in constant motion and seem to act as feelers, and then applying their short, broad snouts to the skin. Their abdomens soon become distended and red with blood, and then, their thirst satisfied, they slowly move off, sometimes so stupefied with their potations that they can scarcely fly. No pain is felt whilst they are at work, but they each leave a small circular raised spot on the skin and a disagreeable irritation. The latter may be avoided in great measure by pressing out the blood which remains in the spot; but this is a troublesome task, when one has several hundred punctures in the course of a day. . . In the course of a few days the red spots dry up, and the skin in time becomes blackened with the endless number of discolored punctures that are crowded together. The irritation they produce is more acutely felt by some persons than others. I once traveled with a middle-aged Portuguese, who was laid up for three weeks from the attacks of *piûm*, his legs being swollen to an enormous size, and the punctures aggravated into spreading sores.

I have by no means exhausted the list of the insects of medical importance which I observed during my short trip to the Amazon. Enough has been said, however, to make it quite clear that the complete control of insect pests in the tropics is a truly Herculean task. Perhaps the reader may even have gathered the impression that the fight is too formidable for the puny efforts of mankind. Yet the findings of entomologists have already paved the way for the ultimate victory, as I purpose to show by two examples taken from the history of yellow fever and malaria.


97,200 Deaths, annually in this country, due to Malaria and Intestinal Diseases, and only
7,000 due to Railroad Accidents.
5,000 Men died of Fly-borne Diseases in the Spanish-American War, and only
300 were killed by Spanish Bullets.

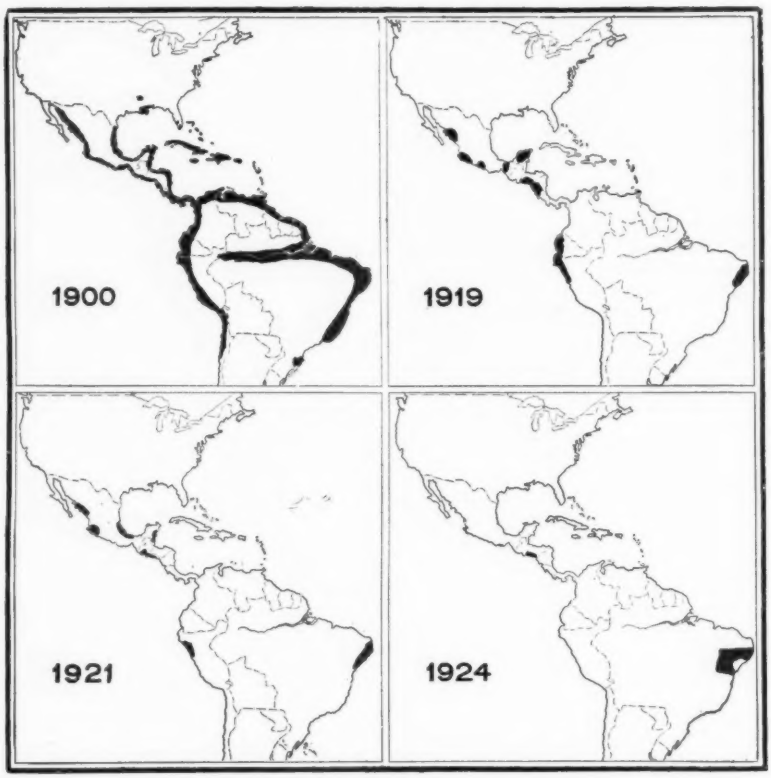
The importance of insects as shown by their effect upon human life. The figures are, of course, only approximate. From an exhibit in the Hall of Insect Life, American Museum

The conquest of yellow fever and its far-reaching results in opening up the tropics would be a fit subject for an epic. For two hundred years at least this dreaded disease had caused great loss of life and much destruction of wealth. Perhaps the deadliest epidemic that ever visited the United States was that of yellow fever in 1878, when in the Mississippi Valley alone more than thirteen

thousand people lost their lives. The Spanish-American War finally focussed attention upon the need of eliminating this disease. At the time it was believed that no newcomer to Cuba could escape it. During the early years of the American occupation of the

Shake, from the deep foundations of the world,
Th'imprisoned plagues; a secret venom oft
Corrupts the air, the water, and the land.

It is true that ever since 1881 Dr. Carlos Finlay had contended, from epidemiological evidence, that a mosquito conveyed the disease, and that he had



Yellow fever is steadily retreating before the attacks of entomologists as is shown by the blackened areas on these maps. Courtesy of the Rockefeller Foundation

island, all efforts to combat it were in vain, simply because the relation between the disease and a certain mosquito was unknown. At Havana, in 1900, there were a greater number of cases than there had been for several years. At the dawn of the century exact knowledge of yellow fever was not much more advanced than when Armstrong wrote:

And though the putrid south
Be shut; though no convulsive agony

even positively incriminated the true culprit, *Aëdes ægypti*. But too little was known at that time of insects as potential carriers of germs for Finlay's arguments to make much impression upon the physician. In 1877 Patrick Manson had shown that a worm, *Filaria bancrofti*, which lives in the human body, develops in the common five-banded mosquito of the tropics (*Culex quinquefasciatus*). So novel was this discovery that even eminent parasit-

ologists received it with scepticism. It was not until 1898, when Ronald Ross, in India, and Grassi, in Italy, demonstrated that malaria is invariably carried by anopheline mosquitoes, that the medical world was inclined to approach the problem of yellow fever with a more open mind. At Havana, in 1900, an American Commission, headed by Dr. Walter Reed, succeeded in transmitting the disease from a sick to a healthy person by the bite of gnats, *Aëdes ægypti*, raised from eggs. In the course of the experiments several other important facts were discovered. These, together with a knowledge of the habits of the mosquito, made it possible to devise effective measures of control. Within a few months yellow fever was eliminated from Havana where it had existed continuously since 1762, and where even in 1900 it caused 310 deaths. The last case of the year 1901 occurred in September. Fifteen years later Colonel Gorgas was able to write that "with one exception there has been no case of this disease in Havana since that date." Nowadays Havana is a much-vaunted winter resort, while only twenty-five years ago even a brief stay in the city was regarded as almost certain death to the outsider.[1]

The yellow fever mosquito. From an enlarged model in the American Museum

[1]The fascinating story of the conquest of yellow fever may be read in Rubert Boyce's *Yellow Fever and its Prevention* (New York, E. P. Dutton and Company, 1911.)

A glance at the interesting map recently published by the Rockefeller Foundation (p. 142) clearly indicates how a knowledge of the mosquito and its ways is rapidly driving yellow fever from the face of the earth. Formerly this disease was more or less endemic along the Amazon: in 1906 it killed 253 persons at Pará; from 1893 to 1903 there were 142 deaths from yellow fever at Manáos and the number increased to 1386 during the brief period between 1905 and 1913. Means of controlling the transmission of the disease by the mosquito were then applied, with the result that only one fatal case has occurred since at Manáos. At the time of our visit yellow fever was utterly absent from the Amazon Basin, although its carrier, *Aëdes ægypti*, was extremely abundant in all settlements and on board ship.

Mr. Koch-Grünberg, a member of the Rice Expedition, who died of malaria, following a mosquito's bite. Photograph by Hamilton Rice

Malaria-ridden Vista Alegre. In the foreground is the expedition's launch, named for Mrs. Rice. Photograph by Hamilton Rice

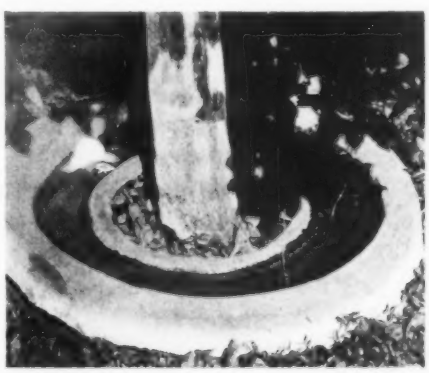
With yellow fever so successfully eliminated, malaria is at present the foremost sanitary problem of Amazonia. The ravages of this disease are not so spectacular as those of yellow fever, yet they are perhaps much more important social and economic factors. A very large proportion of the population along the Amazon and its affluents may be said to be more or less chronically infected, which goes far to explain the prevalent lack of ambition and the physical and mental weakness of the people. Although with length of time the adult natives acquire a certain degree of immunity, they still pay a heavy death toll to paludal fevers. According to Dr. Alfredo da Matta, the eminent physician of Manáos, in that city between the years 1895 and 1914 no less than 12,209 deaths were due to either acute or chronic malaria, accounting for more than 34 per cent of the total death rate. Still, Manáos, Pará, and some of the larger towns along the Amazon may be regarded as relatively salubrious, as much work in sanitation and prophylaxis is carried on, while doctors and hospitals are available for the treatment of cases. Conditions are much worse in the smaller settlements, and in certain areas along the Rio Branco malaria of the most dangerous type is rife. Brazilian as well as foreign observers all come to the conclusion that it is the cause of much poverty and misery and one of the chief reasons for the country's economic stagnation.

Investigation has shown that three factors are needed for the spreading of paludal fevers: man, the malarial germ, and an anopheline mosquito. Malaria is due to a microscopic germ developing in the blood. In order to infect another human being, the germ must pass through an anopheline mosquito, where it undergoes a definite cycle of development. Eventually it produces a form, which, upon being injected into the blood by the bite of the gnat, again causes fever in man. If any one of the three links of the chain be broken, the disease is unable to

A typical scene in a tropical city that has not yet adopted good sanitation. Photograph by James P. Chapin

propagate and soon dies out. This is the basic idea underlying all attempts at controlling malaria. A healthy community may, for instance, keep out paludal fevers, even when anophelines are present, by excluding all infected outsiders or by isolating them in screened rooms until they are cured. Sometimes it is possible to extirpate malaria from an infected locality by isolating and curing all cases, thus preventing the mosquitoes from acquiring the germ. In practice, however, it has been found that it is difficult completely to eliminate all human carriers of malarial germs or to prevent anophelines from becoming infected. As a matter of personal safety in malarious countries one should live in mosquito-proof houses and sleep under a properly adjusted mosquito bar,—the *conopeum* of the Romans; the judicious use of preventive quinine may also be helpful. Sanitarians are now fairly well agreed that in order to eradicate malaria a relentless and intelligent war must be waged against the mosquito carrier.

Undoubtedly in certain regions anophelines are present, while malaria is unknown, because the disease either was never introduced or it disappeared for some reason or other. On the other hand, we may feel quite satisfied that, where anophelines are absent, paludal fevers are not only unknown but are unable to attack the inhabitants even when cases of the disease are introduced from malarious areas. To fight



"From the frying pan into the fire": the moat protects the tree from leaf-cutting ants but breeds mosquitoes. Photograph by James P. Chapin

the anophelines with any chance of success, a thorough knowledge of their habits is a prerequisite. The eggs are laid singly at the surface of the water, where they float for a time before hatching. The larvæ are aquatic, as are those of non-malarial mosquitoes, but, unlike these, they lie horizontally at the surface of the water. The pupæ also live in the water. Both larvæ and pupæ are able to move about and to dive, but they cannot stay any length of time below the surface without drowning. It is in the larval and pupal stages that mosquitoes are most vulnerable, so that the main efforts of the sanitarian must be directed against the breeding places.

The bearings of malaria and other insect-borne diseases on human culture and progress are undeniable. Some years ago, Sir Ronald Ross, while traveling in Greece, was forcibly impressed by the prevalence of paludal fevers in what was at one time the cradle of Western civilization. He argued that the valleys of Greece in the time of the Persian wars could not possibly have been as malarious as they are now. The disease, he supposed, entered the country about 500 B.C. or later, by the introduction of *Anopheles maculipennis* or of infected soldiers or slaves from Asia. It then crept slowly up the valleys, destroying the rural prosperity, without which the subsequent decline of the country was but a matter of time.[2] I am well aware that the argument will hardly appeal to the average historian, especially if he be imbued with what may perhaps be called the "race complex." Yet much might be said to support the biologist's view that there is "no reason to suppose that the Roman and the *Megatherium* were not struck down by similar causes" (Ross).

Moreover, whatever lessons the past might have to teach us, the chief interest of mankind centers in the future. The time is at hand when the most progressive races of mankind will be driven by dire necessity to the virgin fields of endeavor in the tropics. We are far beyond the stage in which mere courage and physical strength fulfill the requirements of success in tropical enterprise. The tropics and their riches will ultimately belong to those peoples who skilfully apply the multiple resources of human knowledge. To insure a healthy, productive, and contented life will be the first problem to solve. It is therefore safe to predict that entomology will have an ever-increasing share in the settlement of equatorial regions. When one reflects upon the present importance of the study of insects in the realm of theoretical as well as of practical science, it is hard to believe that twenty-five years ago entomology was the neglected stepchild of biology. But, like Cinderella, she has come into her own and begins to receive the homage even of those who formerly snubbed her. However, her true triumphs are yet to come in the tropics, where the struggle between insect and man assumes a fierceness not dreamt of by dwellers in temperate climes.

[2]The historical foundation for Ross's theory may be found in W. H. S. Jones's *Malaria, A Neglected Factor in the History of Greece and Rome* (1907) and *Malaria and Greek History* (1909.)

The Friendly Insects[1]

By FRANK E. LUTZ

IT is quite natural that the "average man," whatever that means, thinks that insects in general are pests. The only insects which he notices closely are those that force themselves into his field of thought by attacking his prized possessions or even his more intimate person. It was for this reason that the Persians considered Beelzebub, the "Prince of Insects," to be a devil, and today "bug" means something that does not accord with our notions of what ought to be, whether it is a man who differs from us in opinions and hobbies or a flat, brown creature that lives in some people's beds.

Without doubt there are insects which, so far as man is concerned, are now unmitigated nuisances. In former times, however, even some of the most loathesome of these were made use of. In the days of Dioscorides "nine bedbugs enclosed in a bean" cured fever and Pliny said that a hen which had eaten one bed-bug would be immune for twenty-four hours to the bite of an adder—a sort of a prototype of "an apple a day keeps the doctor away"—but in these enlightened days we take quinine for fever and we have found simpler methods of raising chickens.

However, there are more than half a million different kinds of insects and the wholesale condemnation of the class has been based on sad experiences with one or two hundred. Is that fair? And might it not be well to wonder whether in the remaining hundreds of thousands we have friends as helpful as the few which we are forced to notice are powerful foes? Also, are there neutrals?

There is almost no mammal, bird, fish, or any other back-boned animal, including man, that does not live at the expense of other living things, plant or animal. Live by killing or injuring is the rule of "higher" animals. If most insects follow the same rule, is that to their discredit? But there is an interesting thing about the food of insects: a given species is quite likely to have a very limited menu. A rabbit will nibble any plant that is not actually distasteful or difficult to chew and a cat will eat any kind of bird that it can catch or of mice or of fish or even of grasshoppers, but it is somewhat exceptional to find a species of insect that feeds on anything but closely related plants, if it be a plant-feeder, or on anything but closely related animals, if it lives on meat. Indeed, some species of plant-feeding insects confine their attention exclusively to a single species of plant and a similar limited taste is possessed by many meat-eaters.

Man, either because of his inherent egotism or for some other reason, thinks that the world—and, indeed, the whole universe—exists solely for him. At the same time, there are many kinds of plants for which he has no particular use and the thousands of kinds of insects which feed on nothing but these cannot logically be considered as injurious to him.

Then there are the weeds. "Weed" has been defined as "a plant out of place" and man has usually done the

[1]One of the American Museum's radio broadcasts.

misplacing, accidentally carrying in his commerce the seeds from one country, where the plant is controlled by natural conditions, to another favoring its immoderate spread. Man does not like weeds and should be grateful to the hundreds of different kinds of insects that feed on these unwanted plants.

But what about the insects that feed on the plants that man does want? It must be admitted that there are such "undesirables." I do not know how many undesirable people there are per thousand in an average community—not really criminal but undesirable. Are ten in every thousand, one per cent, poor citizens? Well, there are about 15,000 different kinds of insects in the general vicinity of New York City and less than one per cent of these can be said to be even moderately injurious to either man's purse or his person; somewhat less than "half of one per cent" are, however, decidedly injurious, so injurious that man must fight them vigorously.

Where did these three or four dozen different kinds of insects that threaten our very existence come from? Almost every one is a "weed," a creature that is out of place because man has brought it in his commerce from some other country to this one: gypsy moth, Japanese beetle, European corn borer, Hessian fly, San José scale, and so on, to say nothing of the domestic roaches, house-flies, bed-bugs, and the like.

The gypsy moth is only moderately destructive in its native Europe and the Japanese beetle does no more harm in Japan than do many of our closely related "June beetles" here. Why should the foreigners multiply so mightily in the United States? Without showing how one factor after another cannot explain the phenomenon, we may come immediately to the point that, when man introduced these insects, he failed to introduce other insects which preyed upon and kept them in check in their native homes.

De Morgan (Swift wrote nearly the same thing) was speaking in the direction of the truth when he said:

> Great fleas have little fleas upon their back to bite 'em.
> And little fleas have lesser fleas and so *ad infinitium.*
> And the great fleas themselves, in turn, have greater fleas to go on;
> While these again have greater still, and greater still, and so on.

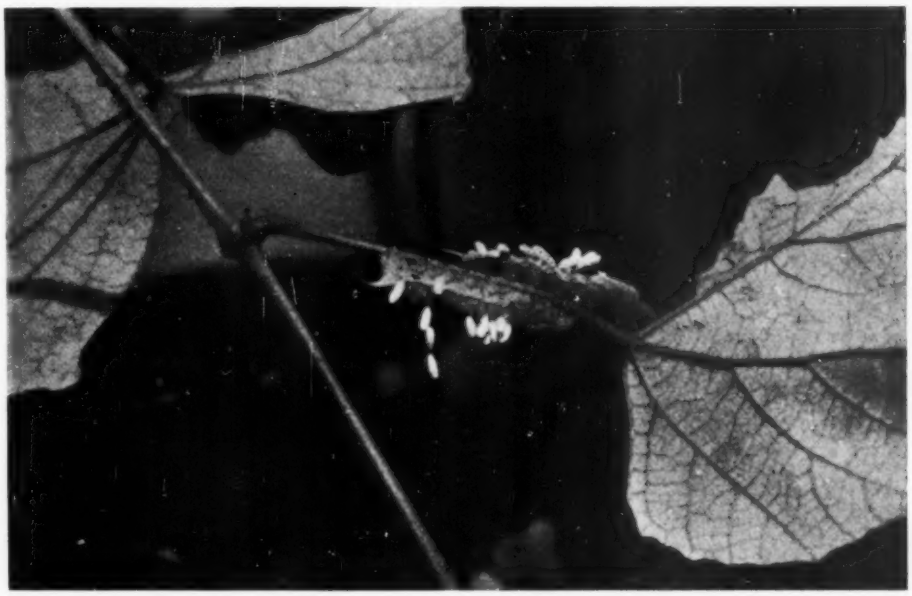
Literally thousands — how many thousands we do not yet know—of different kinds of tiny insects obtain their entire food by eating and killing other insects. Very few birds live exclusively on other birds; very few fish live exclusively on other fish; but relatively few meat-eating insects feed on anything except other insects. On the other hand, there are few, if any, plant-feeding insects that do not suffer from the attacks of these parasites or predators. That is the reason that our native plant-feeders are rarely seriously injurious and then not for long; there is a "balance of nature" when man does not upset it. This balance may swing back and forth, as in the case of the Tent Caterpillar, but it is there.

Now, when man's commerce brings a plant-feeding insect to this country from its native land, the insects which preyed upon and kept it in check there are left behind. The plant-feeder finds itself in a land of plenty free from any effective enemy. No wonder that it multiplies if the climate and food are at all suitable. What is man to do about it? Man upset the balance of nature; let him try to restore it by importing the particular kinds of

insects friends that, all unobserved by him, were fighting his battle for him in the country from which the pest came. This is not always easy to do, since the parasite, despite what De Morgan and Swift thought, frequently has no insect parasites from which it is relieved when brought here, and so it has all the disadvantages of meeting a new environment without leaving the compensating advantage of unusual freedom. If, as sometimes happens, these "little fleas have lesser fleas," it is to our interest to find this out and carefully avoid bringing our friends' enemies here.

Our Government has been doing just these things and with marked success. The work should be heartily supported but the reason for mentioning it here is to emphasize the fact that we owe our lives to thousands of kinds of insects that are in our gardens, our meadows, and our woods,—to thousands of friendly insects that are keeping our native plant-eaters from multiplying to such an extent that our country would become a barren waste unable to support either beast or man.

Then, there is another thing. Suppose a body of men were to say to the rest of us that they would make it possible for us to have delicious fruits and beautiful flowers but in return their relatives would take, say, twenty per cent of the fruits and flowers they make possible. Suppose we could not get fruits and flowers in any other way. Would we consider that body of men or even their relatives unfriendly because of the twenty per cent commission? Scarcely, although we might try to beat the bargain as to the relatives. Insects are doing and since the Garden of Eden have been doing just that. (I hadn't thought of it before, but Man's downfall can be traced to insects, for there would have been no apple for



Leaf-feeding caterpillars bearing on their backs the cocoons of the parasitic wasps that keep them in check. From the film "Winning the Insect-life Merit-badge"

An exhibit in the American Museum showing a bumble-bee on an apple blossom. The bees go to the blossoms to get food for themselves, but in doing so they unwittingly transfer pollen that makes it possible for fruit to follow the blossom

Eve had not some insect carried pollen from another blossom to the one which by reason of that pollen developed into the fatal apple.)

Of course, it would be silly to say that, if insects had never been, we would have neither fruits nor beautiful flowers. We do not and cannot know what other resources Nature might have employed. We do know, however, that for most plants it is well—and for many plants necessary—to have pollen (the plants' male element) brought from some other flower than the one which furnishes the female element (the germ from which, after pollenation, the seed developes). This is particularly true of the flowers which by reason of their showy petals appeal to our sense of beauty, including those which develop luscious fruits. Insects deprive man of about twenty per cent. of his apple crop—in some districts even more—but man would have no apples at all were it not for the many kinds of bees, as well as the butterfliesand other insects, that transfer pollen as they pass from blossom to blossom.

And, then, we must thank insects for our birds, some as beautiful as flowers and with the added charm of song. Small-headed sunflowers in blossom add striking color to my yard and are vibrant with bees and butterflies. The activities of these insects transfer the pollen that insures a good "set" of seed. Then the petals droop, the seed matures and my small sunflower plants blossom anew, but this time into gold-finches feasting merrily on the seeds which they owe to insects. To be sure, grasses and other inconspicuous flowers are pollinated by wind, but this would be a dreary world with grasses as our chief flowers and without the many birds, more beautiful than vultures, that get a

large part of their food either directly or indirectly from insects.

How then does the account between insects and man stand in this world over which he strives to have dominion? With respect to most insects, decidedly in their favor, for either they are living their own most interesting lives without any appreciable effect on man's or they are doing him friendly service of vital importance. A very few insects are causing an immense amount of damage, this damage being done chiefly by species which he has introduced into countries where the particular sorts of friendly insects that prey upon them do not exist. Furthermore, many of the native insects now doing little harm are potentially just as injurious and will "break out" if anything happens to decrease materially the numbers of the friendly insects that are keeping them in check.

Enjoying an apple that was made possible by an insect pollenating the blossom. From the film "Winning the Insect-life Merit-badge"

Man now has apparent dominion over the earth but his dominion is being seriously contested by six-footed animals, a class of creatures that were here long before there was a man or any other hairy vertebrate and that, unless man learns more about them, may cause his destruction. In this battle for life which he is waging, it is a poor policy to study only the enemies and then only those that are most active. We need to know more about our potential but not yet active enemies and much more about our friends among the insects. This is one of the reasons that the American Museum of Natural History started and is conducting (in, as yet, a very small way) its Station for the Study of Insects where living insects may be closely observed in their natural environment.

The Color Dust of the Butterfly

By VERNON KELLOGG
Permanent Secretary and Chairman of the Division of Educational Relations, National Research Council

Doctor Kellogg tells us here what it is that makes the "flowers of the air" so beautiful and points out ways in which a butterfly may benefit by the scales that cover its wings. There is some difference of opinion as to these benefits but the statements made by Doctor Kellogg, which are based primarily on his own personal studies, express the view most generally held.
—The Editor.

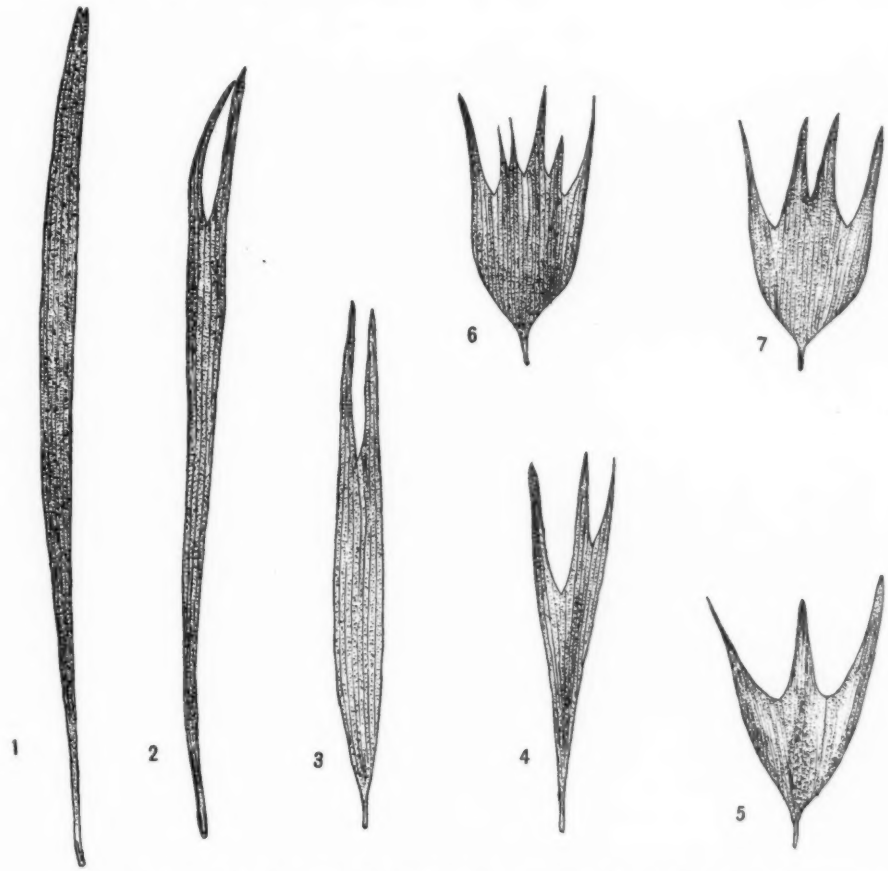
WE call the moths that flutter about the lamps in the evening "millers" because they are covered with "flour." But the dull-colored Miller Moths are not the only moths that are flour- or dust-covered; all of their near relatives, the Hawk Moths which hover, hummingbird-like, at twilight over the honeysuckles and petunias, the great cecropias and beautiful lunas ("pale empress of the night") and all the butterflies, white and yellow, blue and red and varicolored, are covered with a fine flour which rubs off at slightest touch and sparkles on one's fingers, in the sunlight, like diamond dust. This dust of the butterfly is its gold and silver and gems, its silk and satin gown, for all of the beautiful colors and bizarre and delicate patterns of the butterflies' wings are made by it; the ever-changing, metallic reflections of the great blue-green Brazilian Morphos and of our own little Blues and Coppers which dance about the wet spots of the roadways; the rich red-brown of the Monarch and Viceroy, the black and yellow eye-spots of the Satyrs, the silver patches on the hind wings of the Fritillaries, and the tiger bands of the Swallowtails—all are made by the butterfly dust. But so minute are the particles of the dust that to see what they look like as separate bits we must turn to our microscope for aid.

If we rub a little of the dust from the wings of a common white Cabbage Butterfly on a glass slide, and then look at it through the microscope, what a revealing of delicacy of structure and symmetry of outline! And how varied the forms which this butterfly dust presents! While some of the particles are short and broad, others are slender and long; some have smooth, even margins and some have little teeth or points ranged along one edge. Careful looking, however, will pretty soon show us that, despite the apparent variety and difference of shape and appearance, there are certain important points of resemblance and uniformity among the particles.

First, all are of a character which may best be described as scale-like; they are truly little scales. They are flattened, and usually longer than broad, and have at one end a minute projecting stem or pedicel, while the opposite end is usually the broadest part of the scale. Each scale is thus composed of an expanded blade and a narrower stem. We see, also, that the surface of the blade part is crossed from stem end to opposite margin by many extremely fine parallel lines, or striæ; these lines are really little alternate ridges and grooves running along the surface of the scale. The margin opposite the stem end of the scale is either even or from it project the pointed teeth, short or long, few or many, already spoken of. The side

margins of the scale are never toothed but always run in straight or curving lines back to the stem. In length the scales vary from $\frac{1}{350}$ to $\frac{1}{30}$ of an inch, the average length being abuot $\frac{1}{100}$ of one general plan, although the first glance through the microscope revealed an apparently confused variety of objects.

The scales on the microscope slide

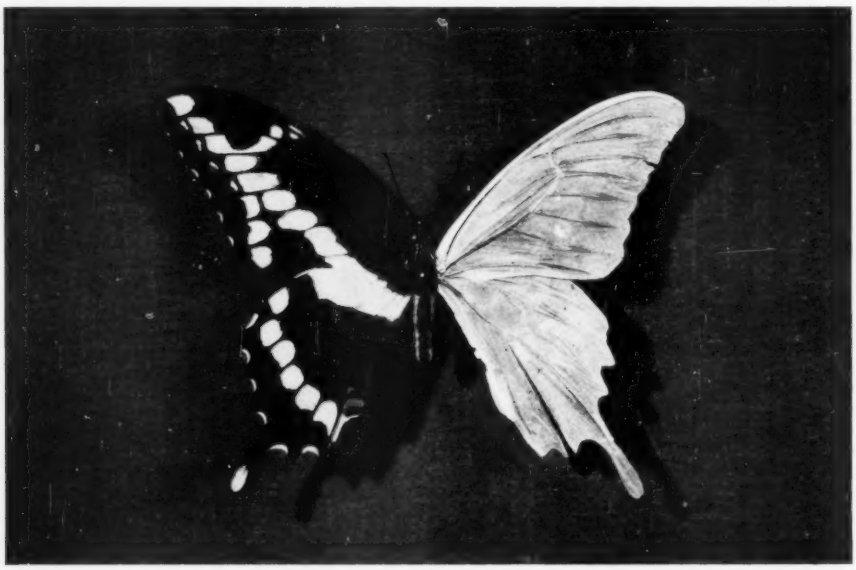


Scales from a moth's wing, showing gradations between a simple, hairlike structure and a broad, pronged one. Very greatly magnified

an inch. If we cut across one of these scales and examine the cut surface, we discover that each scale is a tiny flattened sac with the narrow space between its lower and its upper wall filled with granules of coloring matter, or sometimes simply with air.

Thus this more careful examination of the butterfly's dust shows that it is composed of a host of minute flattened sacs or scales which are all formed on lie in miscellaneous array due to the violence of our handling; on the wings, however, they are bestowed with beautiful regularity of arrangement. If we examine under the microscope a small bit of wing from which all the scales have been rubbed off, we see that the wing surface is crossed by regular rows of little pits or pockets. Into these tiny pits the short stems or pedicels of the scales fit, the scales thus

being regularly arranged in rows running transversely across the wing, i.e., from front to hind margin, all with their stem ends pointing toward the base of the wing (that part nearest the body). And if we examine now a bit of wing with scales on it, undisturbed, we see that the transverse rows of scales are so near together that the ends of the scales of one row overlap the bases of the scales in the next row in front and, besides that, in each row the scales are set so thickly that they overlap each other laterally. By this doubly overlapping arrangement there is formed a complete sheathing or shingling of the scales over the wing surfaces.



A butterfly which has had the scales removed from its right wing, leaving that wing colorless

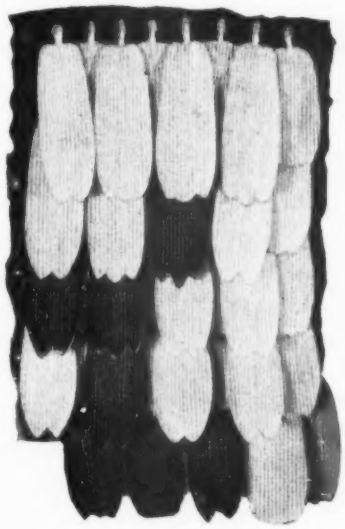
The number of scales on a butterfly's wing is enormous. For example, on the wings of one of the large blue Morphos from Brazil there are 165 rows of scales, with 600 scales in each row, on every square inch of wing surface. This makes 99,000 scales to the square inch. As the under surface of the wing is covered by scales as well as the upper surface and as the upper and under surfaces, combined, of the fore and hind wings have an area of about fifteen square inches, the total number of scales on the wings of a Morpho is approximately 1,500,000.

What is the use of the scales? For one of the first questions that the student of natural history asks in his study of any part or organ of an animal's body is, what is the use or function of this part? The answer to this question in the case of the scales is, I believe, this: they have two principal functions, namely, to strengthen and protect the delicate wing membrane, and to produce the varied colors and markings of the wings. In addition, some of the scales have other uses to which I shall refer later.

The wings of insects must sustain the burden of the insect's body in flight, and must be strong enough not to break or fold when they strike the

air the powerful blows necessary for swift sustained flight. The wings of a butterfly are composed of two thin transparent membranes (an upper and a lower) which are stretched over and supported by a few strong ribs or veins. The veins run from the base of the wing to the outer margin, spreading apart and becoming thinner and weaker as they approach the margin of the wing. These veins can be readily seen if one rubs off most of the scales from the upper and lower sides of the wing. Now, in the wings of most insect kinds there are many short cross veins which connect the longitudinal veins and make the wing skeleton stronger. But in the butterfly and moth wings there are but one or two of these cross veins. The strengthening of the wing membranes is accomplished by the firm continuous sheath of overlapping scales. When the wing beats against the air, the resistance of the air tends to bend the wing at right angles to its length. It is evident that the arrangement of the scales, with long axes at right angles to the direction of the strain, and with the broad tips of one row overlying the narrow stem ends of the row in front, is the best possible for this strengthening purpose. Each scale is also made strong by the fine parallel ridges, or striæ, which run across it in a direction at right angles with that of the strain. The covering of scales also protects, in some measure, the delicate wing membranes from injury, especially from raindrops.

The second and undoubtedly a more important function of the scales, however, is that of producing the varied colors and patterns of the wings. This function may, at first thought, seem to be of little real use or advantage to the butterfly. But many naturalists believe that most of the striking colors and markings displayed by insects, as well as by other animals and by flowers, are of direct help and use to the animal or plant in its life. The butterflies are preyed on by many insect-eating birds and lizards, and any means which will help them to elude their pursuers will be of direct



From an enlarged model of a Cabbage Butterfly's wing on exhibition in the American Museum. Note the regular arrangement of the scales

advantage to them. Keen sight and hearing and smell, and swift flight, should be advantageous. And if the butterflies could be colored and marked in such a way as to cause them to be difficult to distinguish from the leaves or flowers or the ground upon which they customarily alight, so that they would often be overlooked by their enemies, that should also be an advantage.

Now it is evident that just this condition of things obtains in many cases. The Graptas, or Hop Merchants, which appear in the fall, with their brown and ragged-edged wings, flutter about like dead leaves driven in the wind; and

many of the Pierids have the under sides of the wings colored yellowish-green, so that when sitting, with wings closed above the back, on some green-leaved yellow-flowered growth like the mustard, they can hardly be distinguished from the plant.

On the other hand, it may be advantageous for the butterfly to be conspicuous and unmistakably recognized. For example, the common large red-brown Monarch is not liked by birds; it has a bad-tasting acrid juice in its body, and flies about without any attempt at concealment, apparently immune from attack. Its vivid color makes it easily recognizable to any bird and, after a few trials of the ill-tasting morsels, birds let the big, red-brown butterflies severely alone. But there is another butterfly, known as the Viceroy, which is not ill-tasting and would be a choice morsel for any bird that might catch it. But it, too, is let alone by the birds. Why? Because it mimics the Monarch! Its colors and patterns are almost exactly the same as those of the Monarch, and the birds mistake it for this ill-tasting species.

But we must return to the butterfly dust on which depend all this color and pattern that may be of so much importance in the life of the butterfly. How are the color and pattern actually produced?

As we have already learned, each tiny scale, usually less than one-hundredth of an inch long, is really a flattened sac, whose two opposite walls do not quite touch. The narrow inner space between the walls in some scales is empty, in others it is more or less nearly filled with fine colored particles, pigment granules. The color of the scales possessing pigment is that of the pigment, because the thin membrane walls of the scale are always transparent. Thus, if all the scales on a butterfly's wing contain brown pigment grains, then the wing itself will be colored solid brown. But very rarely do we find a butterfly's wing entirely of one color. And so we find on a single wing scales similar in shape and size but containing differently colored pigments.

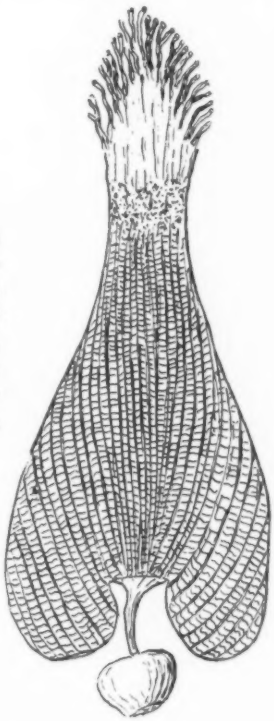
Scales produce color in still another way. Everyone has seen butterflies with wings whose colors are iridescent or metallic, changing in tint as one views them from different angles. The common little Lycænas, the Blues that dance about springs and wells or wet spots in the roads, have colors of this kind. Now, if one rubs some of the scales from a wing which has these iridescent bluish colors and puts them on a glass slide under a microscope, allowing the light to shine through them from the mirror below (examination by transmitted light), one will find, on looking through the microscope, that these scales are not blue at all but either contain brownish pigment or are entirely empty and transparent! If, however, we put something dark under the glass slide, allowing no light to pass through the scales (examination by reflected light), they will again show their metallic changeable blue tint. Indeed, it is not necessary to examine the scales under a microscope. If we hold a *Lycæna* butterfly with wings outspread between the eye and a lighted window or lamp, the wing will no longer appear to be blue but will be a dull yellowish-brown. Hold it down toward the floor or against a dark wall and it will regain its shining blue and greenish tints.

This difference is explained by the character of the structure and arrangement of the scales. Whenever rays of light fall on a series of transparent

superposed plates, as for example a number of thin glass plates placed one on top of the other, the eye perceives various shining colors caused by the interference of the light waves. Illustrations of the production of these colors are numerous and familiar, as in the beautiful colors of the soap bubble, and of oil films, and the prismatic rings which are shown by pieces of mica or by bits of weathered glass. Now, recalling the arrangement of the scales on the wing membrane, the regularly overlapping rows and the lateral overlapping in each row, is it not obvious that we have on the butterfly wing exactly the means necessary to produce physical colors, namely, a series of superposed transparent plates, composed of the delicate transparent walls of the scales? And the colors resulting from this structure and arrangement of the scales are those brilliant metallic blues and greens which vary and change with the changing point of view.

But the scales produce physical colors in yet another way. Remember that each scale bears on its surface many fine parallel ridges, or striæ. Now, brilliant physical colors are produced (by interference) when rays of light are reflected from any surface which has on it very fine ridges or cut-in lines. This, of course, is familiarly illustrated in physical laboratories by the finely ruled Rowland and Rutherford gratings. The ridges on the scales are very fine; on the scales of the Monarch butterfly the ridges are $\frac{1}{12500}$ of an inch apart and on certain scales of the Brazilian *Morpho* the striæ are only $\frac{1}{35000}$ of an inch apart. This striated structure of the scale therefore also produces physical colors.

Two other functions are sometimes subserved by the scales. There can often be found on the upper sides of the wings of male butterflies scales of peculiar shape more or less numerously distributed among the more usual scales of the wing surface. These peculiar scales, when highly magnified by the microscope, give evidence of having many fine openings on the surface or at the tip, and it has been proved that a strong-smelling, usually aromatically fragrant substance exudes from these fine pores. These androconia, as the fragrant scales are called, occur commonly on the male of the familiar white cabbage-butterfly, for example, and if one of its wings be rubbed between the thumb and finger you can smell on your finger-tips this butterfly scale odor. The odorous scales are possessed only by the male butterflies and the scent is supposed to be attractive to the females.



A butterfly's scale that is specialized in such a way that it gives off an odor. Very greatly magnified. Only males have such scales

As to the other of the two special functions, certain butterflies are known

to make faint squeaking noises, and these sounds are produced by the rubbing together of the fore and hind wings. Unusually large and strong scales arranged in a series of rows in particular places on each wing are the structures which produce the sounds.

Finally, we may examine our scales again with another question in mind. Naturalists believe that all the seemingly intricate structures and organs of an animal's body have been developed from more simple structures. If so, what is the simplest, the most generalized, type of the scales?

Among all insects the commonest covering structure of the wings and body is hairs. The simpler and older kinds of insects have hairs on their wings. Can the butterfly scale, with its broad blade and its handle-like stem, its pigment granules, and its effective color-producing structure be derived from insect hairs; be in fact simply a modified or specialized hair? The examination of almost any butterfly's wing will prove this to be the case, for on almost any moth or butterfly wing a series of gradatory forms between simple cylindrical tapering hair and flattened, stemmed scale can be found. The transition from long slender simple hair to broad flat scale most commonly occurs by a slight widening of the tip into two, three, or more branches or fingers lying in one plane, or by the gradual shortening of the basal part of the scale-hair, accompanied by a widening and "filling-in" between the bases of the fingers. This "filling-in" or palmation in the perfect scale may extend almost or quite to the tips of the "fingers," or the fingers may remain as long as the broad blade part of the scale or longer. There is thus produced a flat scale with more or less shortened stem, and with the margin opposite the stem entire or two- to several-pointed, the points being of greater or less length. The fine longitudinal ridges, or striæ, appear with the first widening of the hair. Another common mode of transition is shown in the wings of the cossid moths. Here the scale-hair first widens and flattens at its tip; there is then a gradual shortening and widening for a considerable distance behind the tip so that there is formed an elongate, rather spoon-shaped scale, which continues shortening and widening, the point of greatest width coming nearer and nearer to the tip of the scale. There is thus produced a short broad scale with rounding truncate outer margin, the scale being widest at this margin. The margin is entire, no fingers or teeth appearing anywhere in the course of the development.

Thus the dust of the butterfly is revealed to us as possessing an intricate structure, as disposed in symmetrical arrangement on the wing surface, and as of important use in protecting and strengthening the wings, producing colors and patterns, giving off odors, and making sounds. Finally, the origin and evolution of the scales from simple hairs is readily to be seen.

A similar study, with similar results, may be made of any of the other parts of the butterfly body. The odd shapes, the strange structures, the peculiar habits of insects have meanings, the discovery of which requires careful and persistent study, which is nevertheless always delightful and fascinating. The solving of each particular problem gives us for reward that pure pleasure which is the mainspring of the scientific seeker's endless questing, the happy consciousness of the personal discovery of one of Nature's ways.

Some Interesting Habits of Our Native Bees[1]

By HERBERT F. SCHWARZ
Research Associate in Hymenoptera, American Museum

IN a radio talk recently delivered by a member of the department of entomology of the American Museum you were told that it is only through the constant vigilance of our insect friends that we are able to escape the destruction of our insect enemies, and you were given an insight, too, into other ways in which mankind has benefited from the often unnoticed activities of insects. But I should feel sorry if you thought they had no other claim upon our gratitude than as destroyers of the injurious of their kind or as agents in bringing our fruits to maturity. They have an interest for our mind as well as for our pocketbook. Just as birds are appreciated today not merely for seconding the efforts of our insect friends in policing the fields and orchards but more especially for the beauty and charm they add to life, so the time may come, I trust, when without undervaluing the economic side, there will be a more general recognition of the fascinations of insect behavior and a more impelling curiosity to pry into its mysteries. No matter what group you may select for observation, you will be sure to feel, as your knowledge deepens, a sense of awe at the intricacies of life revealed by these fellow denizens of our planet. Bees, regarding which I am privileged to speak to you tonight, have a fascination that is inexhaustible, but other workers in entomology will claim—and possibly with justice—that the group in which they are interested offers just as thrilling a field for study.

When I say bees, most of those who are listening in will doubtless think of the hive-bee and indeed not one talk but many might be devoted to this wonderful insect. I must resist the temptation to tell you something about this bee: the precision with which it builds its comb; the nice division of labor within the colony by which the newly emerged bees assume the task of tending and feeding their younger sisters while those a little older range over the fields gathering nectar and pollen; the restricted life of the queen, whose days are spent in the darkness of the hive egg-laying; the curious provision of nature whereby the bees are able through special feeding of the larva to produce a queen bee instead of a worker; and other phases of these highly organized insect societies. I say I must resist the temptation, for my topic is concerned with our native bees and, strange as it may seem in the case of an insect so abundant everywhere in our fields, the hive-bee is an alien from the Old World that was unknown in the Western Hemisphere before man introduced it along with his sheep and his pigs, his cows and his horses.

To our wild bees let us then turn our attention. They constitute, indeed, a very large group. Some conception of the variety of forms may be had when it is stated that more than 150 species have been recorded from the state of Connecticut alone. Some of our species are, of course, of relatively wide distribution, but others are of comparatively restricted range. In Europe there are some 2000 species

[1]One of the American Museum's radio broadcasts.

and, considering the extent of our country and its contrasted life conditions, it is safe to assume that when our bee fauna is completely known, it will considerably exceed this total.

Among the flower-visiting insects which attract the attention of everyone are the bumble-bees. During the days of May, in the vicinity of New York, the huge queen is conspicuous as she flies noisily humming from blossom to blossom. At a time of the year when ladies are laying aside their winter furs, Mrs. Bumble appears clad in a brightly-hued mantle of pelt. But she wears it not from vanity but from necessity. It is not a garment to keep off the chill of spring nights but part of her working equipment. Those furlike hairs that clothe her thorax and abdomen, when viewed under the microscope, are found to be branched and their function is to sweep up the pollen that lies in the flowers. The pollen grains that are thus captured in the hairy envelopment of the bee are brushed together by her, moistened, and ultimately plastered on the polished surface of her hind legs along which they work their way upward as more and more pollen is added from below. Finally, the bee, with great lumplike attachments of pollen adhering to her hind legs and her crop full of nectar, flies heavily laden back to the nest, which not improbably is located in the deserted hole of a field-mouse. Within, there is as yet no active colony of worker bees. In fact, not a wing is stirring, for, unlike the hive of our honey-bee, whose populations carry on from year to year even though the life of the individual is brief, the nest of the bumble-bee is an annual affair, founded in the spring and deserted in late summer or fall. At that time the old queen, the workers, and the males die, and only the young queens, usually the last-born of the brood, survive to spend the winter in seclusion, awaiting the call of spring before they in their turn each seek out a nest and establish a family.

At first all of the duties of the nest devolve upon the queen. The pollen she has gathered is deposited in a pile, and in a little wax cell constructed on this pile is laid the first batch of eggs, which in turn is covered with a thin protective papering of wax. As the larvæ emerge and grow, the mother bites through this layer of wax from time to time in order to deposit additional food or, in the later stages, to feed the growing infants individually. Most interesting of all, perhaps, is her habit of incubating the eggs, for when she is not employed in other duties, she is found extended over the little wax enclosure. In front of her is a wax container full of liquid honey and from it she takes refreshment every now and then. The habit of covering her brood hen-wise does not cease with the emergence of the larvæ or even with their pupation, for when the time comes for the larvæ to spin their cocoons, these cocoons are often so arranged that the queen can sit enthroned upon them. Before the first-born members of the colony have reached the adult stage, the queen has laid additional batches of eggs, but before the larvæ that emerge from them are very far along, their elder sisters have matured and have begun to take over many of the duties previously shouldered by the queen alone. Her place in life henceforth is confined to the nest itself, laying eggs some of which, as the season advances, will develop into males.

The fact that in the early broods only females are represented serves to

emphasize the very unimportant part that the male plays not only among the bumble-bees but among all bees. The female is the progenitor of the race in an unusually complete sense of the term, and upon her devolves the task of building and furnishing the nest, and of providing the bee-bread for the brood. Here is a feminism in which responsibilities have taken the place of rights.

There are several species of bumble-bees in the vicinity of New York and the life histories of these bees, like their color and the proportions of their body parts, have their points of difference.

The bumble-bee is one of the social bees. Indeed it and its guest *Psithyrus* are the only social bees other than the hive-bee that are found in our latitude. All the other bees are solitary. By solitary we do not mean necessarily living in isolation, for some of the solitary bees already approach a social condition by selecting nest sites in more or less close proximity to others of their kind. Certain bees of the family Halictidæ even have a common entrance-way leading to nests that are otherwise independent, much as apartment-house dwellers ascend a common elevator shaft to reach their separate establishments. But by "solitary bees" we mean those that have no real contact with their offspring and that hence form no colonies or families. The solitary bee, like the social bee, forages industriously, seeks out appropriate nest sites, and carefully prepares them. But when she has deposited the nectar-moistened pollen in the cell awaiting its reception and has laid her eggs upon this food supply, she seals up the cell and flies away. She does not interest herself further in the fate of her offspring.

Among the solitary bees none are more fascinating than those belonging to the family Megachilidæ, and of all the Megachilidæ I would assign first place from the standpoint of interest to the Leaf-cutters. These bees build their nests in cylindrical hollows,—a reed or the hollow stem of a bush furnishes an excellent nest site. In the darkness of these shafts they construct their cells, thimble-shaped enclosures of leaves, the pieces of which are so perfectly fitted together, with resulting compactness and firmness, that, even when the stem is opened and the cells are removed, these retain their shape, resembling in their totality a green bar. Yet the leaf particles of which the cells are made must be cut in the fields and gardens, perhaps far from the nest itself. Those intended for the side walls must be of an oval shape, those with which the mouth of the cell is sealed must be of a perfect rotundity and of just the right diameter so that they may firmly close the orifice of the cell. The bee has no compass or instrument of precision with which to make her measurements; for cutting-tools she has only her jaws. Yet she works without hesitation and the figures she snips out of the leaves are shaped as though they were intended to illustrate a textbook of geometry. No wonder that in former times, when ignorance of nature was greater, men finding these nests thought them the work of witchcraft!

Every summer I make it a practise to lay out in the garden hollow reeds, and now and then I am rewarded by having a *Megachile* build in them. Even more satisfactory is it to observe the bee at work among the leaves. When you go to the country this summer, see if you cannot find some tree or bush with leaves the edges of which have been defaced with circles and ovals. If you will tarry at the spot, you

will be fairly certain to see the insect artisan return to her quarry, for the bee is apt to visit again and again the same plant and, more often than not, several of her kind are seeking building material for their independent nests at the common source of supply. Why they should concentrate their attack upon a single plant when others of the same kind, and apparently equally suitable, are often growing close at hand, I cannot tell you, unless it is that the bee, who is a very methodical person, follows the conservative principle of "letting well-enough alone."

Belonging to the same family as the Leaf-cutters are several interesting genera. Bees of the genus *Osmia* sometimes employ a kind of green paste that derives its color from the leaf material contained therein and with this substance fashion their cells. Bees of the genus *Dianthidium* are partial to the use of resin in constructing the compartment in which the larva is to live and undergo change, awaiting the time of her "coming out," for the bee, too, has her *début* and, considering that her childhood is spent in darkness and solitude, her entry into the great world may, for aught we know, have even more *éclat* than that which we associate with a flight into the social world. Then there is the genus *Anthidium*, the females of which use soft flocculent material scraped from plants, and in this cottony envelopment establish their nurseries. The bees of these genera, all members of the large family Megachilidæ, carry their pollen not as do the bumble-bees and most other families of bees, on the hind legs but on the under side of the abdomen. For the purpose the female has a dense covering of hairs on this part of her body.

But the Megachilidæ are only one of the many families of solitary bees. Some of these families, like the Xylocopidæ and the Ceratinidæ, are known as carpenter bees because they are expert wood-carvers; others, like the Andrenidæ and Halictidæ, tunnel their nests in the earth. Far down in the scale of the bees is the family Prosopidæ,—little black, almost hairless bees with yellow markings that give them a wasplike appearance. They do not carry pollen, as do other bees, on the outside of the body but swallow it and later regurgitate it with the nectar they have similarly swallowed.

From of old we have been taught to regard the bee, like the ant, as the symbol of industry, and mortals, too inclined to follow the genial ways of idleness, have been urged to pattern their lives after these insects. And yet among the bees as among the ants there are those whose only source of livelihood is preying upon others. There are parasitic genera of bees the females of which lurk about the nest sites of industrious bees and, when a cell has been stocked with pollen and is about to be sealed, slip cautiously in and lay their eggs upon the gathered store. *Psithyrus*, the parasite of the bumble-bee, goes even a step further, brazenly making her home in the nest, not infrequently stinging to death the legitimate ruler and always, to some extent at least, usurping her place. *Psithyrus* rather resembles her victim but some other parasitic bees—the Nomadidæ for instance—are very wasplike in appearance. It is interesting to note that the parasitic bees have no pollen-collecting apparatus and would be unable to rear a brood if it were not for their craftiness in laying their eggs upon the stores gathered by others.

But let us turn from these degenerate members of a noble order and in closing

emphasize a few of the things we owe to these insects. From of old the hive-bee has given us honey. In a cave discovered in 1919 in Valencia, Spain, is a picture made thousands of years ago showing a man of the Glacial Age removing a honeycomb while an angry swarm buzzes about him. Honey was sold in the markets of ancient Egypt. It used to be cheap in those days, fetching only about five cents a quart. Much more important, however, is the service performed by bees in pollenating the flowers. There are whole groups of plants that would disappear from the earth if it were not for the visits of these indefatigable insects. The flower-starred meadows would soon be barren, many of our fruits would cease to ripen; the world would be a dreary place indeed. In New Zealand red clover would not set seed until the bumble-bee was introduced into the islands. It is said that the turtle-head flower is dependent solely upon the bumble-bee, and the bee *Colletes latitarsis* apparently confines its visits almost exclusively to the flowers of the *Physalis*. If you would have the world a flower garden, conserve the bees or, to put the same thought in a little different form, spare our native wild flowers and the bees will see to it that seed is set and that thus the beauty of the floral world is renewed from year to year.

A rock painting at the Cuevas de la Araña northwest of Biscorp, Valencia, Spain, representing a gatherer of wild honey in prehistoric times. The bees are disproportionately large but allowance must be made for the tendency to magnify the antagonist when the attack is vicious. The original painting is in red. A copy of it was made by W. K. (1921) and published in Obermaier's *Fossil Man in Spain*, and that copy is here reproduced, natural size, thanks to the courtesy of the Hispanic Society of America

Principal Orders of Insects

By A. J. MUTCHLER AND FRANK E. LUTZ

MANY lovers of natural history seem to be overawed by the number of different species of insects and the hopelessness of ever learning to recognize them all. The numbers are indeed vast and nobody—not even the most learned of professional entomologists—can tell the specific name of each of the insects living within a few miles of his home. In such a case, what is the amateur to do?

Opinion differs concerning the answer to this important and oft-repeated question. Some advise the amateur to take up only a small portion of all the insect fauna of his region. That cuts down the problem, to be sure, but it deprives one of the joy of knowing about the great majority of the living things that are all around him.

Let us take some actual figures. In the 1910 list of the insects of New Jersey compiled by John B. Smith, there are 10,385 species enumerated from that state. These are assigned to 3,486 genera. The genera are distributed among 331 families and, finally, these families are grouped into orders, of which there are 22.

It doubtless would be possible for a careful, industrious student of New Jersey insects to learn to recognize its 3500 genera. He probably would find by the time he had finished that there are 3600, but that is another matter. However, if our amateur were content just at first to learn to recognize families, the task would be decreased to about one-tenth. Would that be worth while?

So far as we know, no one has deliberately set out to learn the characteristics of all of the families of insects and has accomplished it, without first becoming so interested in some certain family or group of families that he became a specialist. But there are certain very definite advantages to the amateur in learning families first. One of these advantages is, of course, that his problem is reduced to practical proportions. Another is that there are several books on American insects available that will help him to recognize all of the principal families. But still another and a great advantage is that, once you know the habits of one member of a family, you have what is usually a fairly accurate outline of the habits of the other members of that family. And, after all, it is the great diversity and interest of insects' habits that give a general knowedge of entomology its charm.

Learning to recognize twenty-two principal orders of insects is an even simpler task. This is comparable to learning to tell the difference between turtles and snakes or between cows and whales. The chart that forms the Supplement to this issue of NATURAL HISTORY has proved very useful in nature-study classes, Scout rooms, and the like. We hope that it may be useful to many of you and that the rest of you will pass your copies on to some one who may care to have them. The brief statements made on the chart are not in every instance universally true—exceptions are the rule in entomology—but they will serve in most cases.

UNIV. OF MICH.

SWALLOWTAILS

and (above) their less ornate relative, the Clouded Sulphur (*Colias philodice*, under side on the right). Just below are the male (left) and female Asterias Swallowtail (*Papilio polyxenes*). Finally, we show the male (left) and female Spicebush Swallowtail (*P. troilus*)

Our Common Butterflies

By F. E. WATSON AND F. E. LUTZ

In this case "our" refers to the vicinity of New York City, although most of these species are widely distributed. Haunts, food-habits, and life histories are given in tabular form following the text.—The Editor.

THE graceful flight and beauty of adult butterflies have made them the most popular insects, but in their youth they have in the eyes of many people little beauty and can only crawl and eat. They are "horrid caterpillars," poisoned by gardeners and shunned by all except the few who see in them the possibilities of maturity. However, not all caterpillars develop into butterflies; the greater number become moths, and some creatures which strongly resemble caterpillars are really quite different from either butterflies or moths.

A useful distinguishing characteristic of insects is the possession of three pairs of true legs. Nothing else which the amateur is likely to notice has just this number. Spiders have four pairs and centipedes have many; they are not insects. Now a caterpillar *appears* to have more than three pairs of legs, but it will be seen upon close examination that the three front pairs are the only ones which are jointed. The other "legs" are not true legs but merely fleshy props. Young leaf-feeding beetles do not have these props and young saw-flies (relatives of wasps) have five or more pairs in the middle of the body, whereas young butterflies have four pairs and a pair of claspers at the hind end of the body.

When young Lepidoptera have eaten their fill once they cast off the skin they have been wearing and get a larger one. This process is repeated three or four times, and finally they are full-grown caterpillars. Then, if they are young moths, they seek a suitable place and usually spin a cocoon of silk threads. Inside of this they molt once more, but instead of becoming a larger caterpillar each turns into a mummy-like pupa. If they are young butterflies, the fundamental process is

An Asterias Swallowtail caterpillar. Note the two kinds of legs

the same but no cocoon is made. The pupa, which is also called a chrysalis, hangs naked. Perhaps the single thread around the body of some of them and the silk which fastens the tail to the supporting surface represent the moth's cocoon.

The distinction between adult moths and adult butterflies is largely a matter of habits and "feelers." The antennæ are a pair of appendages on an insect's head which are popularly called "feelers," although, as a matter of fact, insects smell and possibly hear with their antennæ as well as feel. The antennæ of butterflies are threadlike and have a knob or swelling at the tip. The antennæ of many moths are clearly feather-like. In others the plumules are not visible to the naked eye and the antennæ look like threads but they

almost never have a swelling at the end large enough to be confused with the knob of butterflies. Then, too, all our butterflies fly only in the daytime, while all but a very few of our moths fly only at night.

SWALLOWTAILS

These are the giants of our northern day-fliers and belong to the genus *Papilio*. The conspicuous resemblance of their hind wings to the "swallow-tails" of the sartorial art and their large size distinguish them from all of our other Lepidoptera except the pale-green night-flying Luna. The *Papilio* which is largely yellow and has, among other black markings, three or four short black bands on the front half of each front wing is the Tiger Swallowtail. Sometimes the female of this species has the yellow replaced by sooty brown except for the marginal spots. This form is rare with us but is quite common in the South.

The Asterias Swallowtail is about as common as the Tiger. Its young feed on parsley, carrot, celery, and parsnip leaves. The adult male may be recognized by the row of yellow spots across the middle of the wings. These spots are sometimes much reduced in the female. The row of blue spots, inside the marginal yellow ones, is more distinct in the female than in the male.

The Spicebush Swallowtail, our commonest species, has a single or at most an incomplete second row of greenish-white spots on the front wings. The hind wings are usually suffused with greenish in the male and bluish in the female. Its larvæ feed on sassafras and spicebush leaves.

WHITES

A white butterfly is a common sight and a guess that it is *the* Cabbage Butterfly (*Pieris rapæ*) will almost always hit the mark. There are really three kinds of white butterflies in the Northeast whose young feed on cabbage and allied plants. Two of them are natives, but the third was accidentally brought from Europe to the vicinity of Quebec about 1860. Since that time, aided doubtless by further importations, it has spread over the whole country and, like its compatriot the English sparrow, it has alargely replaced its native relatives in the more densely populated regions. The European Cabbage Butterfly has the tips of the upper side of the front wings black; there are two black spots on each of the front wings of the female and one on those of the male; the under side of the hind wings is yellowish and without markings.

With us the Mustard White, or Immaculate Cabbage Butterfly, has practically no markings on the upper surface of the wings, although in other parts of the country it is subject to many interesting variations.

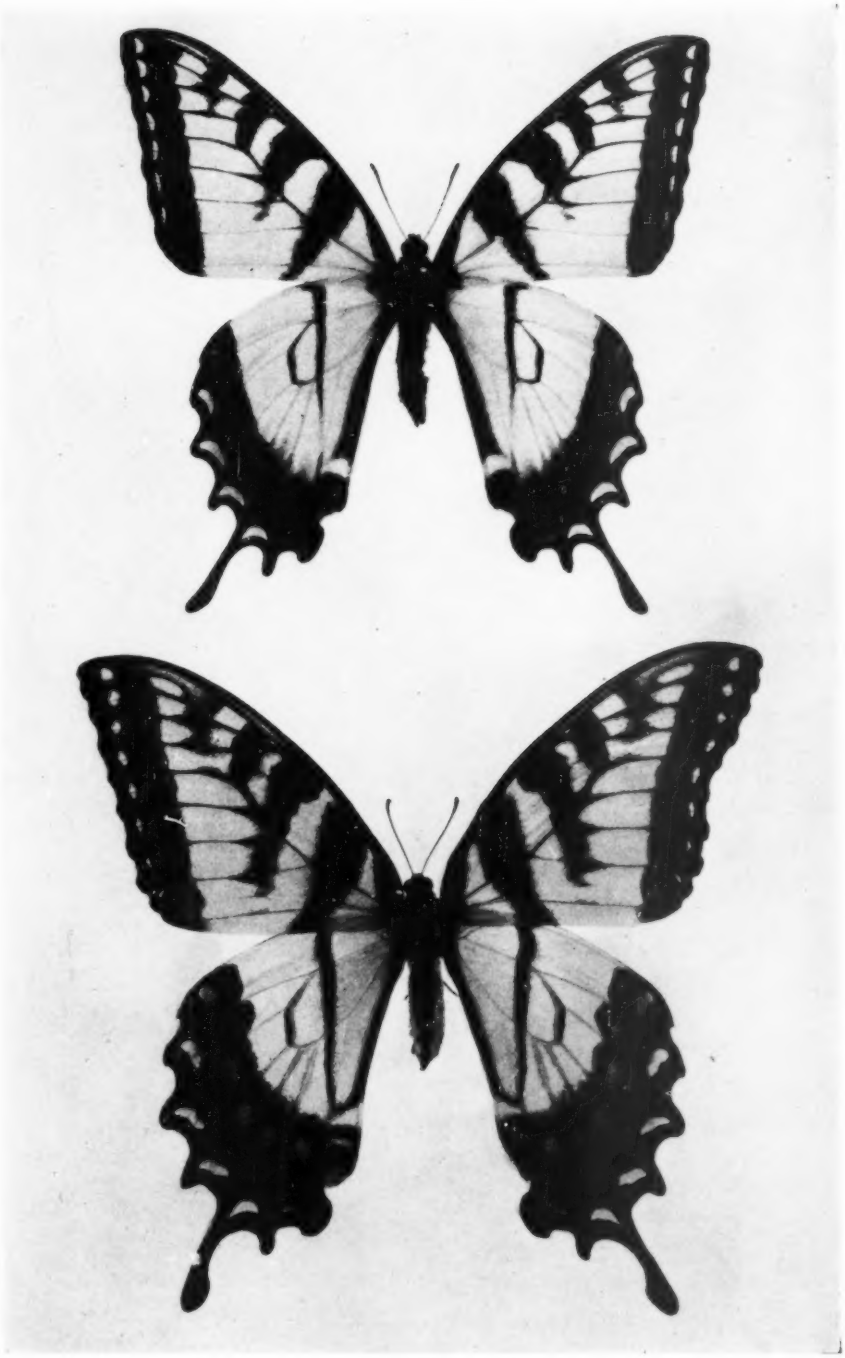
The Checkered White, or Southern Cabbage Butterfly, has no definite black tips to the front wings, but it has two or three distinct black spots on the upper surface of each in the male and many dusky spots in the female.

There is a pretty little White that may be recognized by the green marbling on the under side of the hind wings. It is called the Falcate Orange-tip from the shape and color of the front wings, although only the males are orange-tipped.

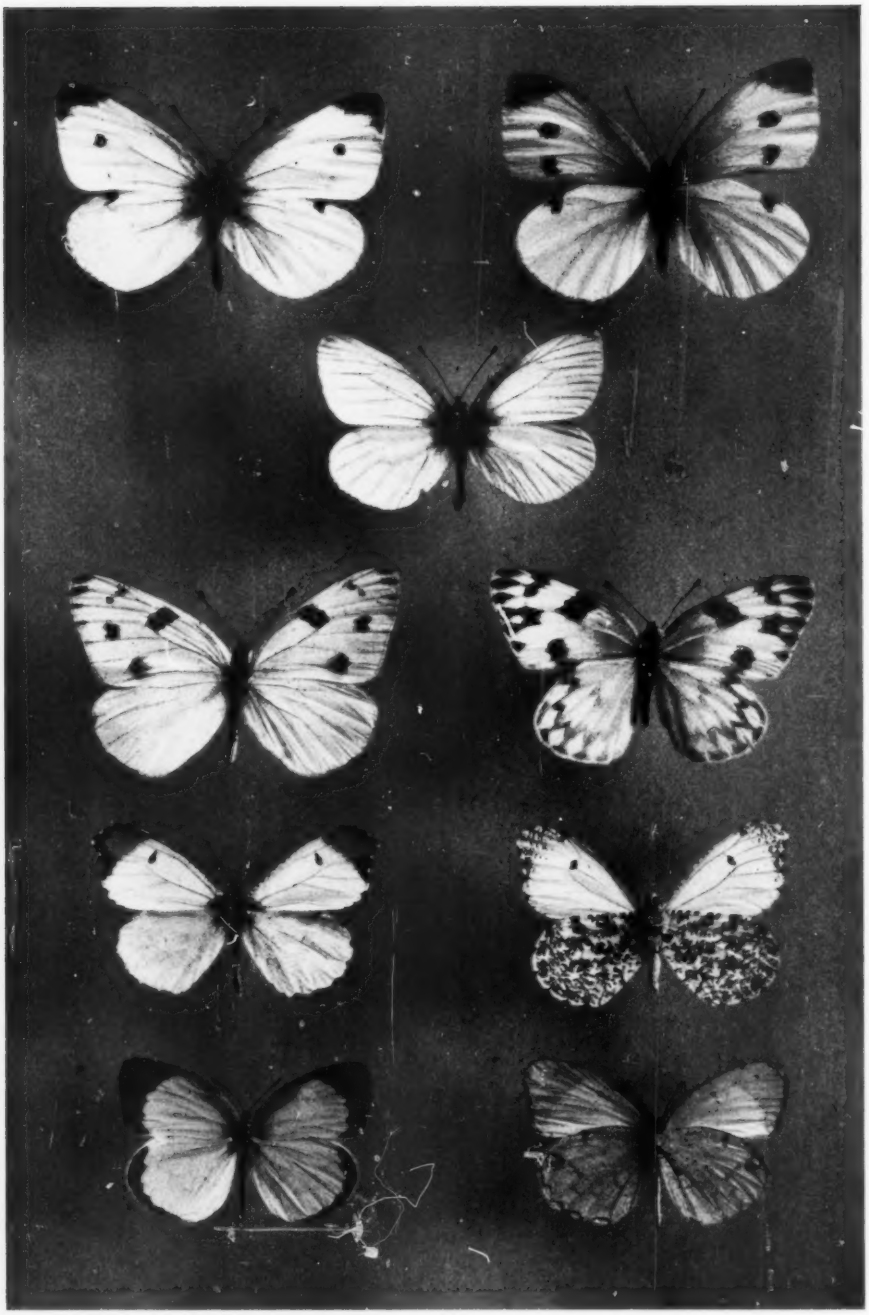
(See also the next section.)

YELLOWS

Several species of yellow butterflies are closely related to the Whites just described. They nearly all feed on clover and its allies. It should be re-

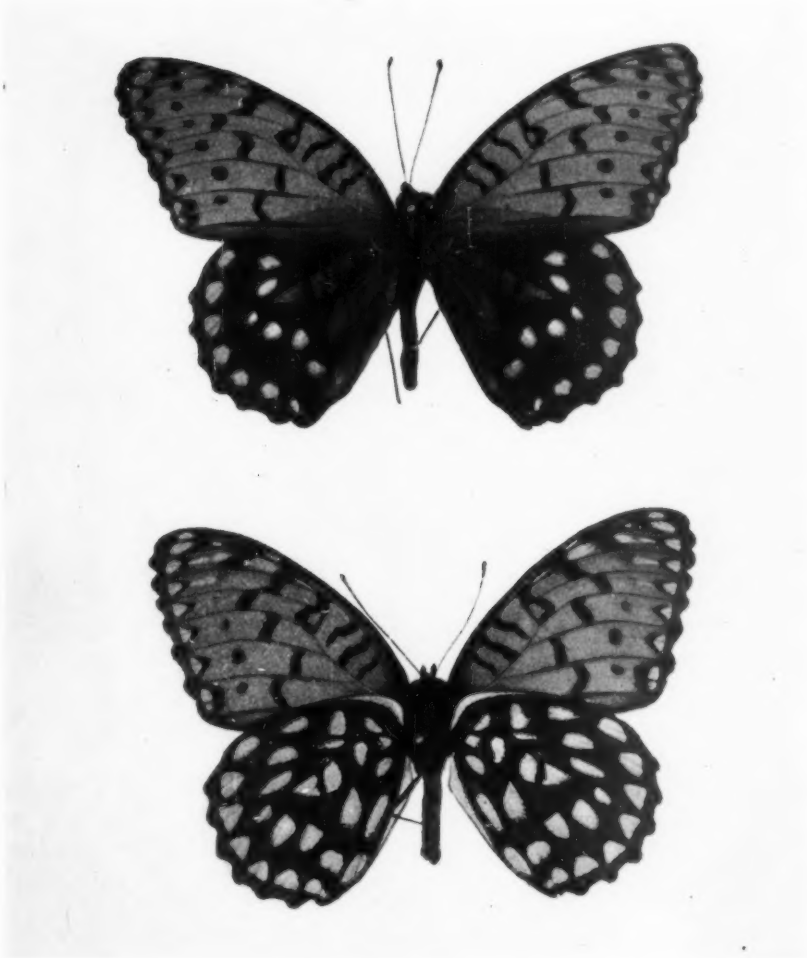


TIGER SWALLOWTAIL (*Papilio glaucus*)
Male, above; female, form *turnus*, below



WHITES AND YELLOWS

From above downward.—Cabbage Butterfly (*Pieris rapæ*); male, left, and female. Mustard White (*P. napi*). Checkered White (*P. protodice*); male, left, and female. Falcate Orange-tip (*Anthocharis genutia*); male, left, and under side. Little Sulphur (*Terias lisa*); male, left, and under side



Regal Fritillary (*Argynnis idalia*); male, above, and under side

marked parenthetically that when the food of a species is mentioned we mean the food of its young, for adult butterflies do not eat. At most they sip water from wayside pools or nectar from flowers through a coiled tubelike mouth which entirely lacks teeth or even jaws.

The most common Yellow in the Northeast is the Clouded Sulphur. It may be distinguished from the Little Sulphur by its size and by the presence of a silvery spot on the under surface of each hind wing. Occasionally the normally yellow parts of the Clouded Sulphur are white but the silvery spots differentiate it from the Whites. This variation is confined to the female.

THE FRITILLARIES

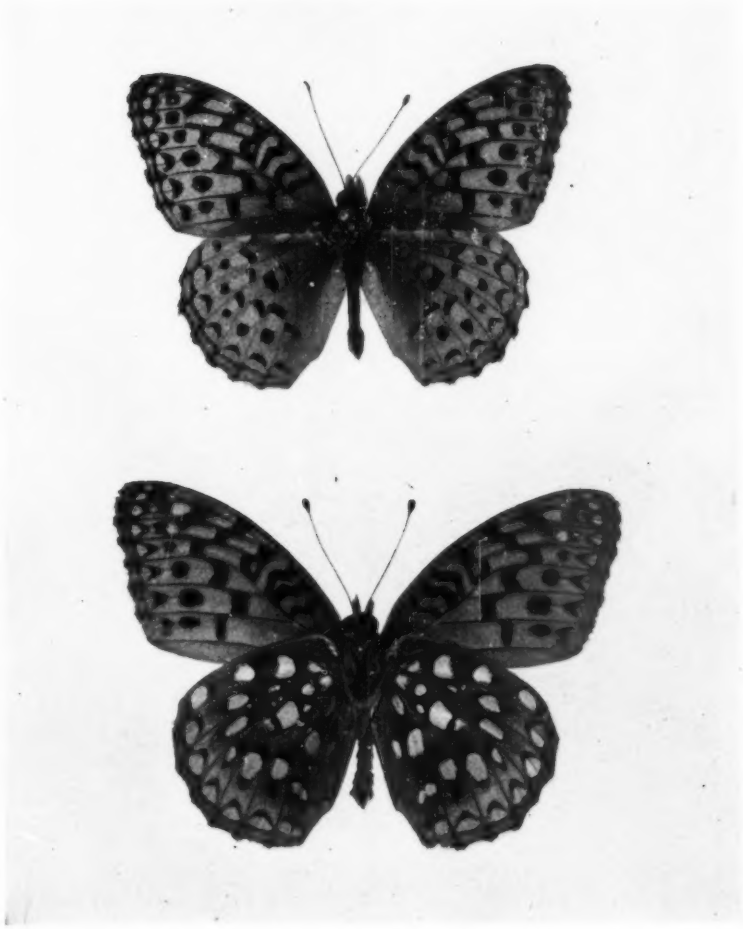
Three of our Fritillaries have a wing expanse of at least two inches. They are tawny or tawny-red above, variously studded with silvery white spots below. The upper surface of the hind wings of the Regal Fritillary is nearly black but the base is tawny and there are two rows of light spots. The outer

Great Spangled Fritillary (*Argynnis cybele*); male, above, and under side

row of these spots is tawny in the male, both being whitish in the female. The Great Spangled and Smaller Spangled have no white markings on the upper surface and the wings are darker at the base than elsewhere although not at all black except for spots and irregular bands. It is difficult to distinguish between these two species, the chief difference being on the under side of the hind wings, which in the Great Spangled have a much wider and paler yellow band than in the Smaller Spangled. The latter is the smallest of the three. All of them feed upon violets, as do the Meadow and the Silver-bordered, their smaller relatives. The last two species are very similar on the upper side but on the under side the Meadow does not have any silvery spots.

The Pearl Crescent, which feeds upon asters, should be considered with the last two mentioned, for each has the upper side tawny, closely checkered with black. The under side is yellowish mottled with brown, a whitish crescentic spot near the middle of the hind margin being usually present and frequently accompanied by other similar spots.

The Baltimore has the ground color of both wings black, bordered with



Smaller Spangled Fritillary (*Argynnis aphrodite*); male, above, and under side

orange-red spots within which are two or three rows of white spots. The under side is similar to the upper but with additional spotting. This butterfly is subject to great variation. During the season in which they are born the caterpillars are gregarious, living within a web with which they envelope their food-plant, the Turtle-head and, less commonly, allied plants. After molting three times, the whole colony hibernates within the web, made more dense for the purpose. In the following spring, they leave the web, disperse, and feed upon a great variety of plants.

ANGLE-WINGS

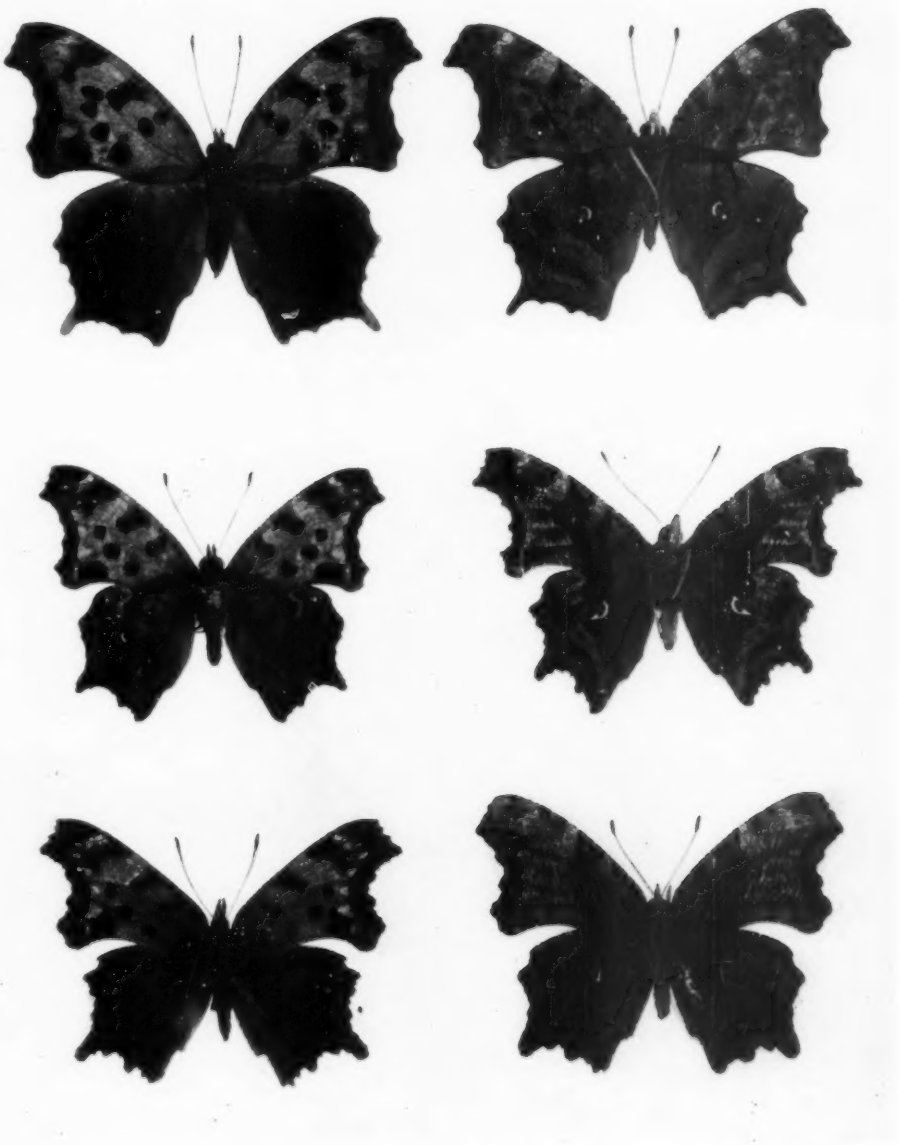
The Angle-wings "look as if Mother Nature had with her scissors snipped the edges of their wings, fashioning notches and points according to the vagaries of an idle mood." The wing expanse is about two inches and, while the upper surface is tawny, variously marked, the under surface is a combination of brown and gray which corresponds so closely with the color of dead leaves that an Angle-wing at rest on the forest floor is extremely well hidden.

The Violet-tip has a tail suggestive

From above downward (under sides on the right).—Silver-bordered Fritillary (*Brenthis myrina*); Meadow Fritillary (*B. bellona*); Pearl Crescent (*Phyciodes tharos*); and the Baltimore (*Melitæa phaëton*)

of the Swallowtails. The upper surface of this tail and the adjacent marginal portions of the hind wing are tinged with violet. On the under side of each hind wing there is a pair of silvery markings which are somewhat like an interrogation point. The young feed on elm leaves.

The Hop Merchant or Comma has a silvery comma or parenthesis on the



From above downward (under sides on the right).—Violet Tip (*Polygonia interrogationis*); Hop Merchant (*P. comma*); and Gray Comma (*P. progne*)

under side of each hind wing and there is considerable yellowish color on the under surface of both pairs of wings. The first name given here refers to the feeding habits of the young but wood-nettle is the preferred food-plant.

The Gray Comma or Progne has a silvery marking similar to that of the Comma but smaller, and the under

Mourning Cloak (*Aglais antiopa*); upper, above, and under side

surface lacks yellow. Its young prefer the leaves of currant and gooseberry.

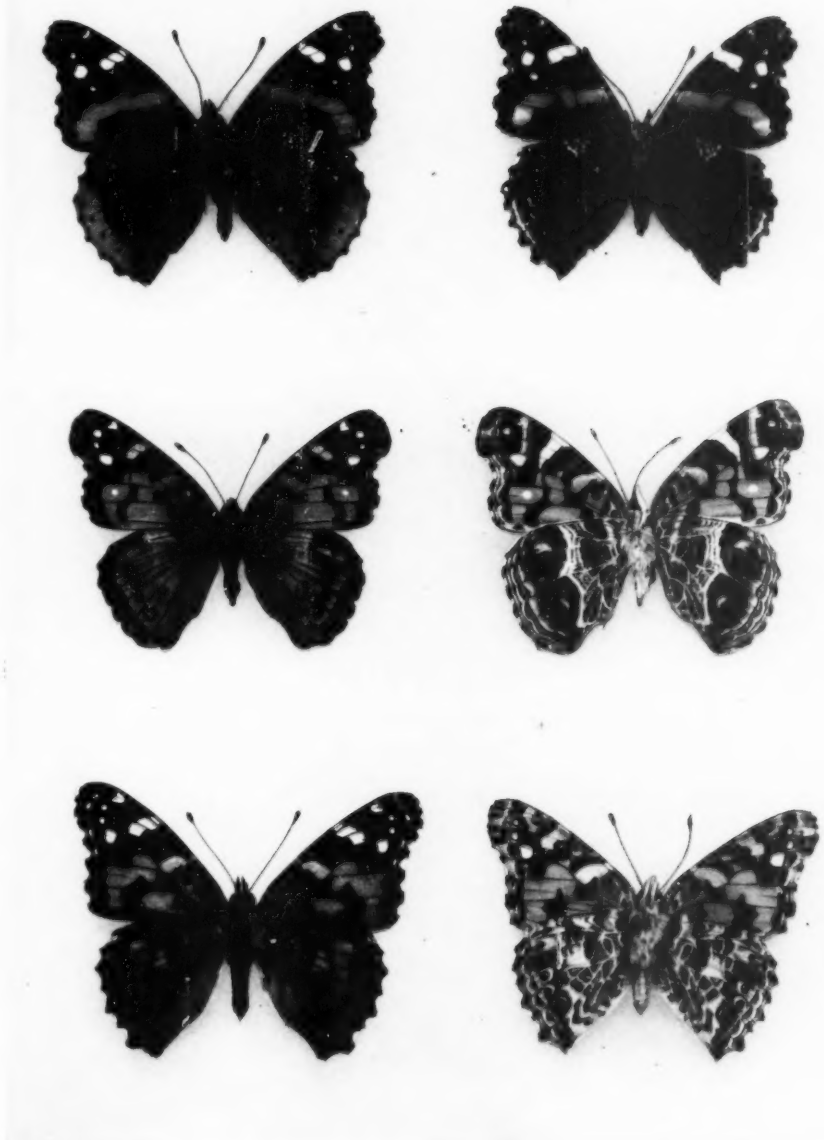
The Angle-wings hibernate as adults.

VANESSAS

The Red Admiral has "eye-spots" (circular spots surrounded by one or more rings of a different color) on the under side of the hind wings but they are usually very indistinct. This species can best be recognized by the brilliant red band crossing each black front wing.

Eye-spots are very distinct on the under surface of the hind wings of Hunter's and the Thistle Butterflies. For some strange reason, these, but more particularly the latter, are also called the Painted Lady or Painted Beauty. The Thistle is one of the most widely distributed of butterflies—as widely as the thistles on which it feeds. There are usually four eye-spots on each hind wing, below, these spots being smaller than the two of Hunter's.

The Mourning Cloak, or, as the English call it, the Camberwell Beauty, is blackish with a lighter margin



THREE COMMON VANESSAS

The upper sides are shown on the left; the under sides on the right. From above down they are the Red Admiral (*Vanessa atalanta*), Hunter's Butterfly (*V. huntera*), and the Thistle Butterfly (*V. cardui*). Each of these has also been put in the genus *Pyrameis*, instead of *Vanessa*

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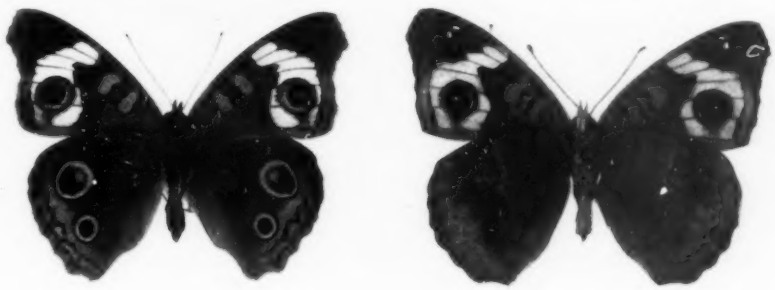
underneath, and blue-black-brownish edged with yellow above. Its spiny young feed on willow, poplar, elm, and the like.

The Buckeye has a narrow orange band near the border of its brown wings. Each front wing is ornamented with a whitish transverse band and a large eye-spot. The hind wing has two of these eye-spots. Beneath, the front wings are similar but duller in color. The hind wings are grayish, brownish, or reddish, with the eye-spots represented by mere spots or dots.



Buckeye (*Junonia cænia*); upper, left, and under sides

The Vanessas, like the Angle-wings, hibernate as adults hidden away under a pile of fence rails, in a hollow log or in some such nook.

THE RULERS

The Monarch, or Milkweed Butterfly, during early autumn assembles in great swarms in the northeastern United States, large numbers hanging quietly from the leaves and branches of trees and shrubs. These flocks then move southward, suggesting the migration of birds. It is believed, but not positively established, that there are return migrants in the spring. At any rate, none of us has ever found the Monarch in the North during the winter, although its black and yellow banded larvæ with their long flexible "horns," and its gold-dotted delicate bluish-green chrysalis are as easily recognized as the adult.

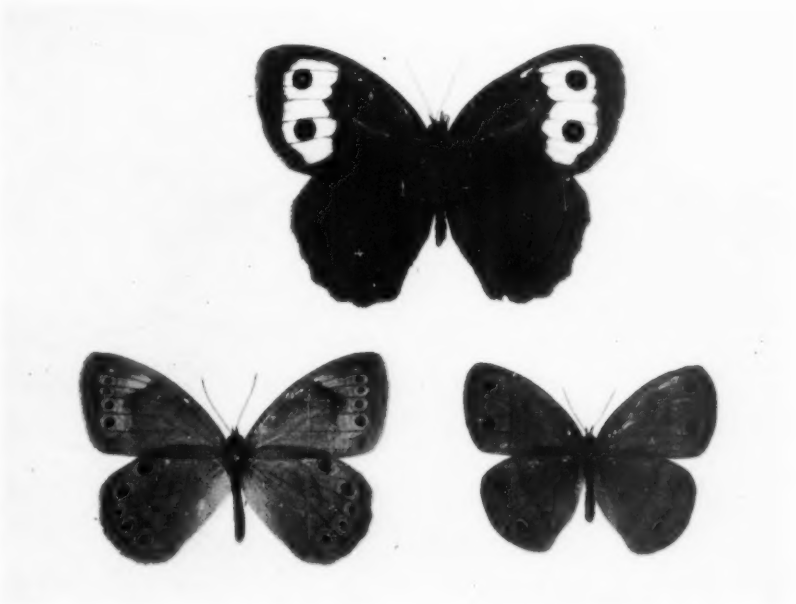
The Viceroy resembles to an astonishing degree the common and wide-spread but not closely related Milkweed or Monarch Butterfly. Its general color is a tawny red; the wing veins are outlined in black, and there is a white-spotted black margin to the wings. So far, the description will fit either species, but the Viceroy has a narrow black band across the middle of the hind wings which the Monarch lacks. Like other members of its genus (*Basilarchia*), it hibernates as a larva in a silken-lined tube formed of part of a leaf of the food-plant and attached to a twig by silk.

The Blue Emperor is also called the Red-spotted Purple, the red spots being at the apex of the front wings on the upper side but more scattered on the lower side. This is, perhaps, our most beautiful butterfly and is subject to great color variation. Some indi-

RULERS

From above downward.—Monarch (*Danus archippus*); Viceroy (*Basilarchia archippus*) and Blue Emperor (*B. astyanax*)

viduals have the red spots on the upper side entirely wanting. In others there is a distinct greenish cast, especially distinct on the hind wings. It has also a very rare form, *albofasciata*, so called because of the white band on both fore and hind wing. This form closely resembles the White Admiral of the Catskills and northward, but white-banded specimens taken in the vicinity of New York City are *albofasciata*.



Common Wood-nymph (*Satyrus alope*), above; Common Grass-nymph (*Satyrodes canthus*), left; and Little Wood-satyr (*Neonympha eurytus*)

THE EYED BROWNS

The common Nymphs have eye-spots on the upper side of the front wings. The general color is brownish. That of the Common Wood-nymph is dark but the eye-spots of the front wings are set in a yellowish band. There are not usually more than two, if any, spots on the upper surface of each hind wing.

The Common Grass-nymph has a row of four small spots on the upper surface of each front wing and the Little Wood-satyr has but two. The brown of both is rather pale and both have the spots on the upper surface of the hind wings "eyed."

HAIR-STREAKS, COPPERS, AND BLUES

We can give only a few examples of this large family of small and often brilliant butterflies. The legs of the slug-shaped caterpillars are so shortened that these creatures seem to glide rather than crawl. The larvæ of many species secrete a sweetish fluid which is eagerly gathered by ants and the larvæ will usually be found with one or more ants in attendance. Of the species mentioned below, the larvæ of the Coral Hair-streak feed at night, and during the day remain beneath the surface of the ground in ants nests at the foot of the food-plant. Their chrysalis is also formed there.

From above downward (under sides on the right).—Gray Hair-streak (*Strymon melinus*). Coral Hair-streak (*S. titus*). Banded Hair-streak (*S. calanus*)

The Gray Hair-streak has the upper side of both wings brownish-gray, with an orange patch on each hind wing. Beneath, the wings are light gray with two dark, white-edged lines in addition to the orange patches. Each hind wing is also provided with a long threadlike tail.

The Coral and Banded Hair-streaks are brown on the upper and under sides of their wings and without markings above. Below, the Banded has two narrow blue bands, and, on each hind wing, one or two orange patches, a blue patch, and a threadlike tail; the Coral has a row of black dots near the center, and a band of coral-red spots (sometimes absent on the front pair) along the margin of each wing.

The American Copper has its front wings coppery-red with some black spots. Its hind wings are brownish with a coppery-red border. The under side is similar but much paler.

The Tailed Blue is a delicate little blue creature which has tails that may be seen by looking closely, but it is apt to be confused with the Common Blue—its extremely variable relative. Each of them has several generations a year, although the latter is frequently called the Spring Azure on account of its abundance when other butterflies are scarce.

From above downward.—American Copper (*Heodes hypophlæas*); male, left, and under side. Tailed Blue (*Everes comyntas*); male, left, and under side. Common Blue (*Lycænopsis pseudargiolus*); male, left, and female; below them three showing variations of under side.

THE SKIPPERS

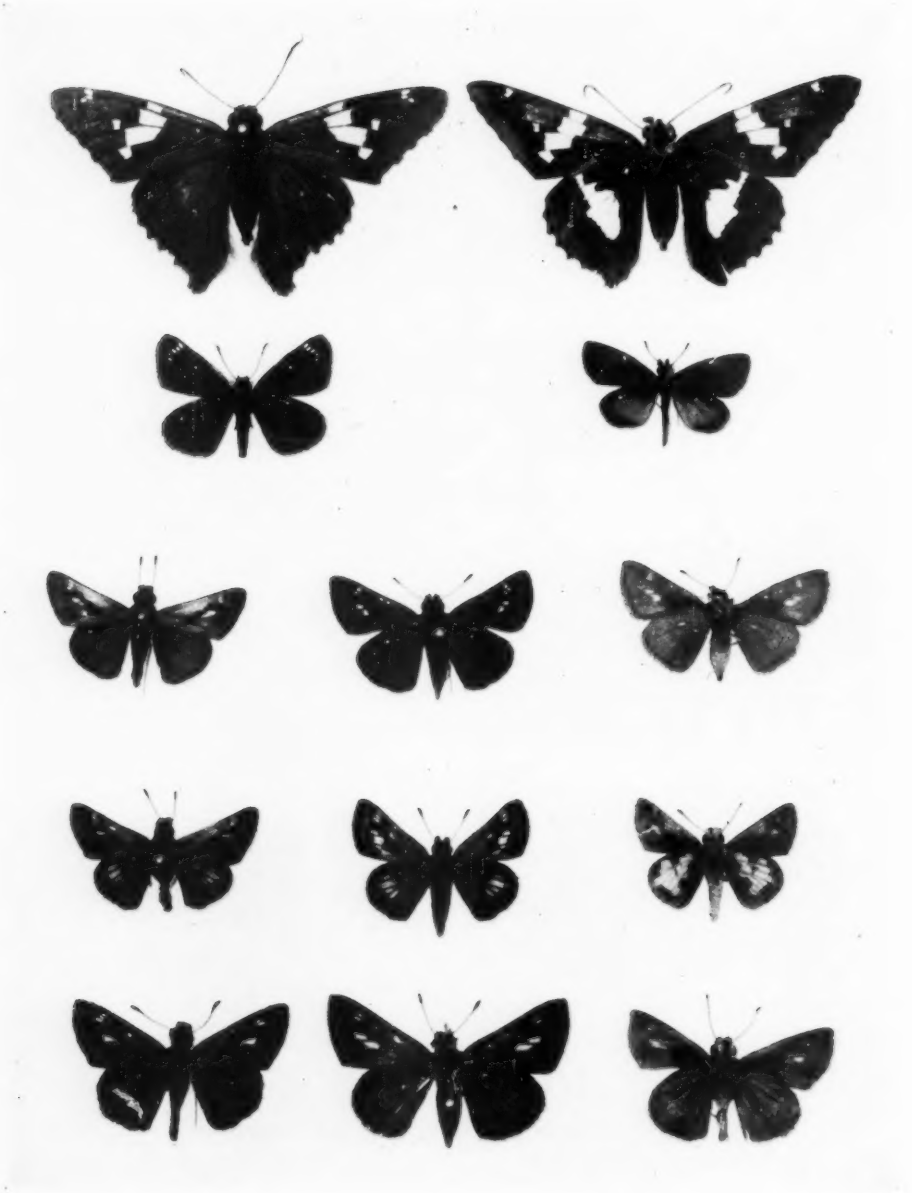
These butterflies, belonging to the family Hesperiidæ, get their common name from their rapid, darting flight. They are, for the most part, small and dull-colored. The sexes of some species differ in the markings on the upper side.

The Silver-spotted Skipper may be recognized by the large silvery spot on the under side of the hind wings. It is extremely pugnacious and will dash at any insect which flies near it.

The Sooty-wing has nearly black wings, the front with some minute white dots; the female has additional indistinct white dots on the hind wing. The under side is similar but paler.

Numitor is called the Least Skipper because of its small size. Its wings are tawny and dark brown. The front wings are generally dark above but have a light front margin below.

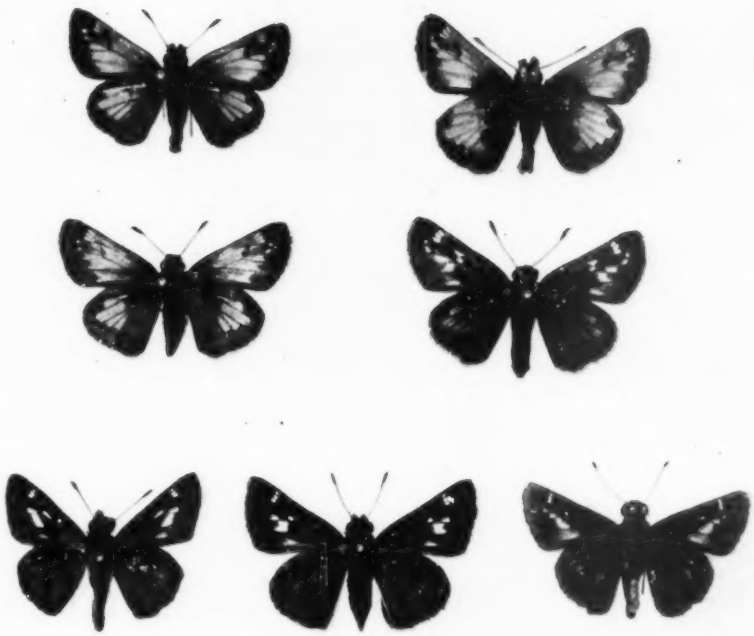
The Tawny-edged Skipper has the front wings in the male tawny with a brown border and the hind wings brown. The female has brown wings



From above downward.—Silver-spotted Skipper (*Epargyreus tityrus*), upper and under sides. Left, Sooty-wing (*Pholisora catullus*); right, Least Skipper (*Ancyloxypha numitor*) Males, left; females, center; under sides, right: Tawny-edged Skipper (*Polites cernes*); Yellow-spotted Skipper (*P. peckius*); Volcanic Skipper (*Catia otho egeremet*)

with a few tawny spots on the front pair, which also have a tawny upper edge in some specimens. Beneath, the front wings are similar but paler; the hind wings are dull greenish-yellow with an indistinct band of minute whitish dots across their centers.

The Yellow-spotted Skipper has



From above downward.—Mormon Skipper (*Atrytone hobomok*); male, left, and under side; female, left, and the variety *pocahontas*. Little Glass-wing (*Atrytonopsis verna*); male, left; female, center; and under side.

bright yellow spots, as shown in the figure, on a brown ground color. These are brighter and larger on the under side of the wings. Other species have similar colors but the pattern is different.

The Volcanic Skipper is dark brown with a few yellow spots on the front wing. The under side is similar to the Tawny-edged, but darker, with the band on the hind wings more distinct.

The Mormon Skipper has two female forms. The typical one is tawny orange with dark brown borders; the other (variety *pocahontas*) is dark brown with white markings. They are less common than the typical form.

The Little Glass-wing has dark brown wings with whitish-translucent spots on the front pair. The under side is similar to the Volcanic, but the spots are whitish, not yellow.

In addition to those already mentioned, there are about twenty other species which are rather common in this vicinity, but longer and more technical descriptions than can be given here would be necessary for their identification. They are, for the most part, Hair-streaks and Skippers, small brownish or brown and yellow creatures which flit before our eyes and then, aided by their concealing colors, disappear.

Explanation of Following Table:

E = Egg. L = Larva (caterpillar). P = Pupa. A = Adult. The "calendar" will vary somewhat with locality and weather.

TABLE OF LIFE HISTORIES

NAME	Nov. to March	April	May	June	July	Aug.	Sept.	Oct.	Preferred Food-plant	HAUNTS
Tiger Swallowtail	P	PA	AEL	LP	AEL	AELP	AELP	P	Wild Cherry	Open Fields and Woods
Asterias Swallowtail	P	P	AEL	LP	AEL	AEL	AELP	LP	Wild Carrot	Open Fields, Meadows
Spicebush Swallowtail	P	PAE	AEL	LP	AEL	ALP	AELP	LP	Sassafras	Open Fields, Woods, Meadows
Cabbage Butterfly	P	PAE	AEL	PAEL	AELP	AELP	AELP	ALP	Cabbage	Gardens, Open Fields
Mustard White	P	AE	AEL	LPA	AELP	LPAE	AEL	LP	Two-leaved Toothwort	Open Woods, Wood Roads
Checkered White	P	AE	AEL	PAEL	AELP	AELP	AELP	ALP	Wild Peppergrass	Open Fields, Waste Places
Falcate Orange-tip	P	AE	AEL	LP	P	P	P	P	Lyre-leaved Rock-cress	Open Woods
Clouded Sulphur	LP	PA	AEL	AELP	LPAE	AELP	LPAE	AEL	Clover	Open Fields, Meadows
Little Sulphur	?	?	?	AELP	AELP	AELP	AELP	A	Sensitive Pea	Open Sandy Fields
Regal Fritillary	L	L	L	LP	PA	AE	AEL	L	Violet	Wet Meadows
Great Spangled Fritillary	L	L	L	LPA	PA	AE	AEL	L	Violet	Wet Meadows
Smaller Spangled Fritillary	L	L	L	LPA	PA	AE	AEL	L	Violet	Wet Meadows
Silver-bordered Fritillary	L	LP	PAE	AELP	LPAE	LPAE	AEL	L	Violet	Wet Meadows
Meadow Fritillary	L	LP	PAE	AELP	LPAE	LPAE	AEL	L	Violet	Wet Meadows
Pearl Crescent	L	LP	AEL	AELP	PAEL	AELP	AEL	AL	Aster	Open Fields, Meadows
Baltimore	L	L	LPA	LPAE	LPAE	L	L	L	Turtle-head	Wet Meadows & Marshes
Violet-tip	A	A	AEL	AELP	AEL	AELP	LPA	PA	Elm	Open Woods, Lanes, Roads
Hop Merchant	A	A	AEL	AELP	AEL	AELP	LPA	A	Wood Nettle	Open Woods, Lanes, Roads
Gray Comma	A	A	AEL	AELP	AEL	AELP	LPA	A	Currant	Open Woods, Lanes, Roads
Red Admiral	PA	A	AEL	AELP	PAEL	LPA	PA	PA	Nettle	Wood Roads, Lanes
Hunter's Butterfly	PA	A	AEL	AELP	PAEL	LPA	LPA	PA	Sweet or White Balsam	Open Fields, Meadows
Thistle	A	A	AEL	AELP	PAEL	LPAE	PAEL	PA	Burdock	Open Fields, Waste Places

TABLE OF LIFE HISTORIES

NAME	Nov. to March	April	May	June	July	Aug.	Sept.	Oct.	Preferred Food-plant	HAUNTS
Mourning Cloak	A	AE	AEL	LP	AEL	LPAE	AELP	LPA	Willow, Elm	Open Woods, Lanes
Buckeye	A?	A	AEL	AELP	PAEL	PAEL	AELP	LPA	Geradia	Open Fields & Roads
Monarch	Absent	Absent	AEL	LP	AEL	AELP	LPAE	ALP	Milkweed	Open Fields, Meadows
Viceroy	L	L	LP	AELP	AEL	ELPA	AEL	L	Willow	Damp Places, Meadows
Blue Emperor	L	L	LP	LPAE	AEL	LPAE	AEL	L	Wild Cherry	Lanes, Orchards
Common Wood-nymph	L	L	L	LP	PA	AEL	AEL	L	Grasses	Grassy Meadows
Common Grass-nymph	L	L	L	LPA	PAE	AEL	L	L	Grasses	Wet Meadows, Swamps
Little Wood-satyr	L	L	PA	AEL	AEL	L	L	L	Grasses	Grassy Places, Edges of Woods,
Gray Hair-streak	P	P	PAEL	AELP	PAEL	PAEL	AELP	LP	Pea & Bean Family	Dry Fields
Coral Hair-streak	E	E	EL	LPA	PAE	AE	E	E	Wild Cherry	Open Fields
Banded Hair-streak	L	L	L	LPA	AE	AE	EL	L	Hickory	Wood Roads & Woods
American Copper	P	PA	AEL	AELP	PAEL	AELP	PAEL	AELP	Sorrel	Fields, Roads, Meadows
Tailed Blue	L	PA	AEL	AELP	LPAE	AELP	AEL	L	Round-headed Bush-clover	Open Fields, Meadows
Common Blue	P	AE	AEL	AELP	AELP	AELP	AELP	LP	Maple-leaved Arrow-wood	Open Woods
Silver-spotted Skipper	P	P	AEL	LPAE	PAEL	AEL	ALP	LP	Locust	Open Fields near Locust Trees
Sooty-wing	L	LP	PAEL	AELP	LPAE	PAEL	AEL	L	Pigweed, Amaranth	Waste Places, Roads
Least Skipper	P?	P	PA	AEL	PAEL	LPAE	AEL	P?	Grasses	Grassy Places, Fields & Meadows
Tawny-edged Skipper	P	P	PA	AEL	AELP	LPAE	AEL	LP	Grasses	Grassy Places, Fields & Meadows
Yellow-spotted Skipper	LP	LP	PA	PAE	AEL	LPAE	AEL	LP	Grasses	Grassy Places, Fields & Meadows
Volcanic Skipper	L	L(P?)	(LP?)	PAE	AEL	AEL	L	L	Grasses	Grassy Places, Fields & Meadows
Mormon Skipper	LP	LP	PA	PAE	AEL	L	LP	LP	Grasses	Grassy Places, Edges of Woods, Meadows
Little Glass-wing	L	L	LP	PAE	AEL	AEL	L	L	Grasses	Grassy Places, Fields, Meadows

ALL THE INTERESTING FEATURES OF A BROOK ARE BY NO MEANS ABOVE THE SURFACE OF ITS WATERS. NATURE HAS HIDDEN MANY FASCINATING INSECTS THERE—WINTER AND SUMMER

Some Residents of a Brook[1]

By WILLIAM M. SAVIN

BY no means all of the interesting features of a brook are above the surface of its waters, nor are they only the scaly vertebrates so tempting to the angler. Nature has hidden many fascinating insects underneath stones on the brook's bottom and others among the submerged plant life, while still others go darting here and there, now up and now down.

Judging by several things, including the respiratory system, scientists believe that many, or possibly all, of our aquatic insects are descendants of truly terrestrial ones. The whirligig beetles that swing their dizzy circles on the surface of the water, now and then diving to escape danger from above, have the same sort of breathing apparatus as the tiger beetles that live on the hot sand of the dryest barrens. However, when they dive they carry down with them a supply of air safely tucked away between body and wings, a tiny bubble usually showing at the wings' tips. The young of these whirligig beetles, somewhat wormlike creatures living entirely in the water, have gills along each side of the body; but these gills are connected with an internal respiratory system that is similar to that of any caterpillar.

Whether adult or young, an insect has in its body a system of tubes that carries air directly to the various tissues. This, you will note, is quite a different arrangement from that of vertebrates where blood goes to lungs or gills for a supply of oxygen which it then carries to the tissues. The gills of the young whirligig beetles mentioned above cover openings into the system of air-tubes, called tracheæ. Through the walls of these tracheal gills the air contained in the body of the insect is purified.

The whirligig beetles swing their dizzy circles on the surface of the water

These beetles, then, are really, as one might say, terrestrial insects living in the water just as whales are terrestrial mammals that have taken to the ocean. In a way they are like toads and frogs, amphibia. However, aquatic beetles make up only a small portion of all beetles and the others are purely terrestrial.

Each principal order of insects has at least a few more or less aquatic representatives, the degree of adaptation to that environment varying from merely an ability to live on the surface of the water to a condition of affairs where the entire life is spent underneath except for short mating flights and journeys from one locality to another. But, all adult insects are fundamentally creatures of the upper air and even those adults that are usually submerged

[1]Illustrations from photographs by the author, except as noted.

must come to the surface to breathe just as whales come up to "blow." Curiously, the orders in which every species has aquatic young, such as the dragon-flies, the May-flies, and the stone-flies, have adults that never enter the water except to lay eggs, and few do even that.

Of the insects living on the surface of the water and rarely going beneath, the water-striders are among the most

Water-striders glide about on still places in the brook, pouncing upon helpless insects that have fallen in

interesting. They are true bugs; that is, they have piercing mouth-parts, four, if any, pairs of wings, and "incomplete metamorphosis." By the latter phrase we mean that the young just hatched from the egg looks much like the adult except that it is small and has no wings. From time to time, as it gets older, such an insect sheds its skin, at each molt becoming larger and looking more grown-up, until finally there comes the molt that discloses the full-fledged adult. These striders glide about on still places in the brook, pouncing upon helpless insects that have fallen in and sucking their juices.

A dragon-fly nymph (left) and the skin of one (right) out of which has crawled the winged adult

The reason that the striders can walk on the water is that their feet are fitted with hairs and lie out flat so that they do not break through the surface film. Even a needle can be floated in this way if it be greased and gently laid flat on water.

It is also interesting that relatives of these striders of still places in our brooks are the only insects of mid-ocean. How such creatures can weather the storms of an angry sea is a mystery. Once they have been submerged and thoroughly wetted they seem unable to regain their ability to float unless they can crawl out on some object and dry themselves. Failing this, they drown; and, yet, there they are in numbers many miles from shore.

The dragon-flies are, perhaps, the most spectacular insects of a brook, darting back and forth like miniature air-planes and making landings on the tips of reeds,—such landings as must be the envy of every aviator that has given them a thought. The young of these dragon-flies live in the water, where they feed on the larvæ (the

A dragon-fly at rest

young) of mosquitoes and other aquatic animals.

Dragon-flies belong to the order Odonata but this order is clearly divided into two parts: the true dragon-flies and the damsel-flies. Quite apart from technical characters we may distinguish the adults of these two groups by the fact that, when they are at rest, the dragon-flies hold their wings out at the sides and the damsel-flies hold them together over their backs. Even the young differ and in a curious way. The young damsel-fly has three leaflike gills at the hind end of the body. These gills not only absorb air from the water but they act as sculling oars when the young damsel-fly wishes to go forward. The young dragon-fly, on the other hand, takes water into the hind end of its body, where there is an air-absorbing surface, and when the young dragon-fly wishes to go forward, it shoots this water out forcibly and pushes itself ahead in this way.

When the young Odonata, dragon-fly or damsel-fly, is half grown or larger, we can notice small pads on its back just behind its head. These are the wings developing inside of its skin. At each molt the pads get larger and finally the youngster crawls out of the water onto a stick or a rock, its skin splits down the back, and an adult, fully equipped with most useable wings, pulls itself out of its swaddling clothes. There is no apparently resting pupal stage, between the larval and the adult

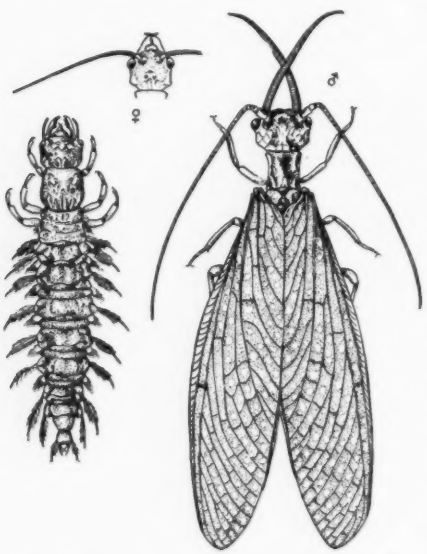
The "swaddling clothes" of a Stone-fly

stages, as there is, for example, in the case of butterflies.

This absence of the pupal stage is characteristic also of other orders of aquatic insects. One of our illustrations shows the split skin from which an adult stone-fly had emerged. May-flies have a similar history but they are an interesting exception to the rule among insects that there is no molt after functional wings have been acquired. When the May-fly "nymph"

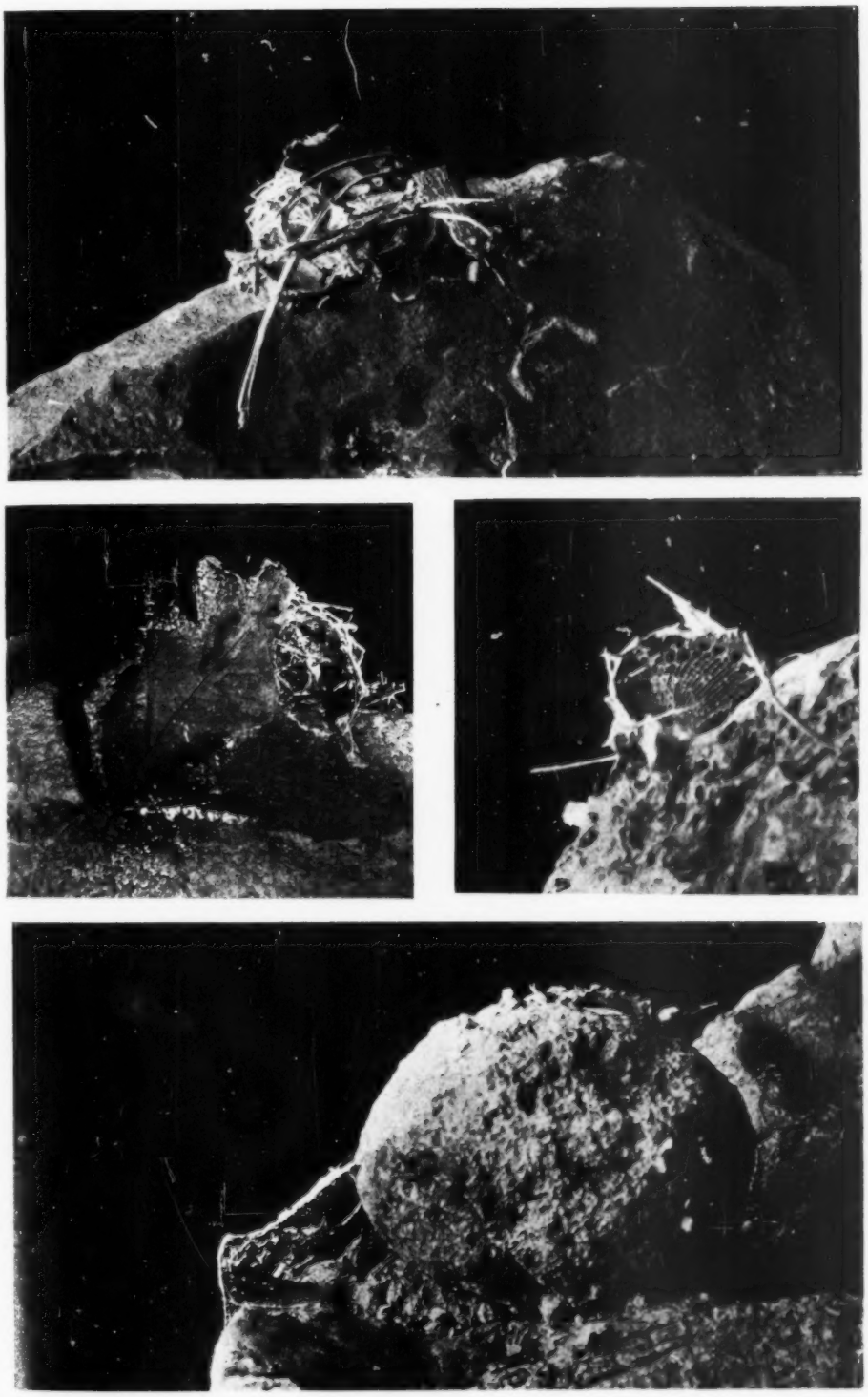
crawls out of the water, its skin splits in the regular fashion, a winged creature comes out, flies around a bit and then its skin splits and the adult May-fly emerges, leaving behind the "subimago" envelope, complete even to the part that covered the wings. This relict looks exactly as though it were all that remained after some enemy had killed a May-fly and picked its skin—not its bones, for it has none—clean. Instead, it is a joyful indication of a freer life—though brief—a life of aerial dancing and mating.

Many a fisherman knows the horrid-looking hellgrammite hiding underneath stones on the bottom of a brook but not all of them know what happens to this hellgrammite if it is not used as bait for bass or some other fish. When its time comes to leave the water of its own accord, it crawls onto the bank and under a stone there. Since it has "complete metamorphosis," it does not immediately become an adult but the skin splits and discloses a pupa. After the insect has spent some time in this stage the pupal skin splits and out comes the adult. It is called a dobson-fly but it is merely the hellgrammite grown up. The accompanying illustration shows the unforgetable appearance of a male dobson-fly and the head of his smaller-jawed spouse.



The hellgrammite (left) pupates and then becomes either an adult male dobson-fly (right) or his more docile-looking mate, whose head is shown above. From Lutz, *Field Book of Insects*

Opinion differs, of course, but to me the most fascinating residents of a brook are the caddis-flies, skilled artisans in wood, stone, or silk, as the case may be, and probably the aquatic branch of a line of descent that gave us the butterflies and moths. The young caddis-flies are wormlike affairs, really not beautiful in themselves but some of them do truly wonderful things. Most of them construct cases in which they live with only their heads and the leg-bearing part of their bodies exposed. Those kinds that live in still water make their cases with light material, some using sticks, others bits of leaves. Of those that use sticks, some place them lengthwise of the body, others crosswise and neatly arranged like the logs of a cabin. The kinds that live in swifter water are more given to using stones or bits of sand and one of these quite unintentionally played a neat joke on the collectors of shells. It builds a case coiled like a snail's shell and makes it of grains of sand so skillfully and so smoothly joined together by a secretion from its mouth that human beings were completely fooled into thinking that the caddis case was really the shell of a new species of snail. Occasionally a caddis-worm that uses stones to construct a case will add a real snail-shell to its masonry, not even rejecting one that still contains a living snail. In such instances many differences of



HYDROPSYCHE'S NET

The worm-like larvae of this genus of caddis-flies builds its square-meshed net of silk in the swiftest part of the brook, facing upstream to catch what may come its way. The upper figure shows the rear of such a net strongly stayed with sticks and pebbles

opinion must arise between the caddis and the snail as to direction of movement.

The young caddis-fly pupates in its case, having first fastened it securely to some under-water support, such as a stone. When the complicated readjustments have been made within the body of the pupa, changing the wormlike young into a mothlike adult, the pupa leaves its case, swims to the surface of the water, and splits its skin. The adult is out and away, sometimes so quickly that it seems as though it had flown out of the water.

In the very swiftest current, where the water rushes over impeding rocks, we may usually find young *Hydropsyche*, builders of stone fishing-huts and traps. Put less figuratively, it is like this. Each of these young caddis-flies constructs out of silk and stone a case for itself securely fastened to a rock. Near this case a frame-work of sticks is made and across it is woven a square-meshed net of silk. This net always faces against the current and the accompanying illustrations show its construction quite clearly. When the young *Hydropsyche* is hungry, it has but to go a few steps—hazardous steps they are, though, in that swift current—from its home to its net, there to eat what the stream may have brought to it.

The larvæ of most caddis-flies live in cases built of sand, pebbles, sticks, or leaves, according to the species. Those that live in swifter water use pebbles of sand as is shown here. At the left is a clump of cases which the owners have fastened together while each pupates within its own

The Insect-hunter Abroad

By T. D. A. COCKERELL
University of Colorado

PROFESSOR COCKERELL, an old friend of the readers of NATURAL HISTORY, is here kindly taking us with him to interesting islands, not seeking knowledge that is of immediate economic value or specimens with which to decorate our homes, but for the pure joy of learning more about the world in which we live.—THE EDITOR.

THE student or collector of insects, when he goes abroad, requires no costly apparatus. A few dollars will purchase net and pins, collecting-boxes and killing-bottles, and all may be stored in a very small space. Having arrived on some foreign shore, in the proper season, he does not search long before he is rewarded with an abundant harvest. Returning home with his collections, whether he studies them himself or hands them to various specialists, he is almost certain to find that he has obtained species new to science, or has learned new things about the distribution or habits of previously known species. During the winter months, his eye wanders over the series of specimens, and he recalls with pleasure this or that expedition, even the various hardships appearing attractive in retrospect. He is not insensible of the fact that many of the specimens are beautiful in form, marking, or color, and is glad to combine æsthetic with intellectual appreciation. Finally, if he can find some like-minded brother entomologists to view his discoveries, listen to his yarns, and envy his success,his cup of pleasure is full, and he resolves that next time he will do even better. Such being the opportunities and rewards, we marvel that there are not more entomological travelers.

It is true indeed that the museums are crowded with insects which no one has time to study. At Oxford I found a couple of bees collected by Charles Darwin on his famous voyage in the "Beagle." To this day they have never been identified. From the Berlin Museum I received a collection of bees obtained by Ferdinand Deppe in Mexico in 1829. So greatly has this fauna been neglected, that several were still new to science, though they were obtained early enough to have been described by Lepeletier. What is the use of piling up materials faster than they can be examined, crowding our collections with huge masses of unassorted specimens?

The matter takes on a different aspect when we think of collecting in order to investigate scientific problems, or merely for the purpose of getting personally acquainted with the wonder and beauty of nature. It is all very well to read about the splendid butterfly *Vanessa tammeamea* of the Hawaiian Islands, each anterior wing with a figure like a red goblin on a black ground. It is a pleasure to see it in a museum, but what is that compared with watching it circle among the trees on the tropical slopes of the Manoa Valley? When one has seen an insect in its natural environment it is possible to think of it as a living thing instead of something dead and done for. When some particular problem is attacked, all the abundance of the museums is likely to prove inadequate. Suppose we are tracing the evolution and distribution of a particular group. Rarely do

STEEP CLIFFS OF THE ISLAND OF KAUAI, NEAR HAENA

we find sufficient specimens for more than incomplete and preliminary discussion. In many cases, it is necessary to collect the material with a particular point in view. We want to know the amount of variation in different parts of an insect's range; we want to know its connection with particular plants, or its habits. We wonder how it maintains itself, and what are its natural enemies. Long and magnificent series in the collections are apt to be puzzling and disappointing. The specimen of a certain butterfly from a certain place is peculiar. Is there then a peculiar race in that locality, or did some collector pick this out from an abundance of ordinary individuals because it was unusual? Recent intensive work on butterflies, as on birds and mammals, has revealed the existence of many local races or subspecies, best appreciated when a long series from each place can be examined. These studies may seem trifling at first, but we are catching evolution at work, seeing the beginnings of differentiation. It is through the study of minutiæ that biology advances, just as it is with chemistry and physics.

There is a peculiar fascination about the fauna of an island, or better still a group of islands. How did the various forms of life get there, and in what manner have they departed from the characters of the original immigrants? What have isolation and special circumstances done for them and to them? Nowhere can these matters be studied better than in the Hawaiian Islands. The splendid *Fauna Hawaiiensis* makes the determination of species relatively easy, yet leaves more than enough new work yet to be done. The islands themselves are charming beyond description, and their people are friendly and hospitable. The climate is healthy, while the United States guarantees security and peace. All this is only five days from San Francisco.

I can never forget July 16, 1924, when Mr. O. H. Swezey took me through the forest on Mt. Tantalus and the upper part of the Manoa Valley. The locality is just above Honolulu, but still retains most of the original fauna and flora. This was the happy hunting-ground of the Rev. T. Blackburn many years ago. In his day the conspicuous black-winged bee *Nesoprosopis fuscipennis* was rare, so rare that he found only a single example of the female sex. I got it in abundance, both sexes. Has it greatly increased in the last fifty years, or did I happen upon an unusually favorable locality at exactly the right time? At the same place we found numerous ichneumon-wasps with dusky wings, bearing a dark spot near the tip. This is *Echthromorpha maculipennis* of Holmgren, and *Echthromorpha* is a genus which is especially characteristic of islands. It is puzzling to know how they cross the sea, apparently having advantages in this respect over most other ichneumons.

At the head of the Manoa Valley I captured a slender, clear-winged dragon-fly, one of Blackburn's discoveries, *Nesogonia blackburni*. It belongs to a genus of one species only, confined to the Hawaiian Islands. Its affinity is with the widespread *Sympetrum*, some species of which probably wandered across the sea long ago, and its descendants have become sufficiently different to be placed in a distinct genus. It is found on several of the islands, and Perkins says: "This dragonfly exhibits much variation in color, size, and other respects, and both general variability and local are evident." There is thus an oppor-

tunity for intensive study, with the certainty of interesting results.

On Mt. Tantalus we are again reminded that we are following Blackburn's footsteps by taking a beautiful little butterfly, uniform emerald green on the under side of the wings. It is called *Lycæna blackburni*, and is peculiar to the Islands. I met it again near the Volcano House on Hawaii. On the way down the Manoa Valley, I found a brilliant shining purple ladybird beetle. It is *Orcus chalybeus*, imported by the economic entomologists to feed on scale insects. My specimen is a female, with dark-lobed prothorax; in the male these lobes are cream-colored, so that the sexes look at first like different species.

The insects of the islands may be divided into several groups on the following bases: (1) species belonging to genera which are confined to the islands; (2) belonging to genera also found elsewhere, but the species peculiar to the islands; (3) species also found elsewhere, but probably not introduced by men; (4) species accidentally introduced, and (5) species purposely introduced. The introduced species are now very abundant, and in the vicinity of towns or along the coast appear to be dominant. The interrelations of these different groups, which naturally react on each other, afford endless opportunities for study. Furthermore, among the endemic species, some are widespread, others confined to particular islands, or even to very restricted localities on those islands. In the museum it is difficult to understand the meaning of all this, but in the field certain facts are obvious. Thus we may see how, close to the Volcano House on Hawaii, there are abrupt changes in climatic conditions, so that in a few minutes one may pass from one environment into another which is radically different. Insular endemism within the group is a never-failing source of interest. How far are the species of the several islands distinct from one another? Which islands have most recently been formed, or most recently been connected with others, judging by the fauna? Can we, by very careful statistical studies, discern the beginnings of insular differentiation in species which occupy several islands?[1]

Of all the islands, perhaps the most interesting is Kauai. Far to the northwest, separated from Oahu by a channel which it takes all night to cross in the inter-island steamer, it naturally shows a large proportion of peculiar organisms. *Carelia*, a remarkable genus of snails, is entirely confined to it and to the neighboring small island of Niihau. Kauai is believed to be of relatively great antiquity and, although thousands of feet of volcanic strata are exposed in its deep cañons, volcanic activity is entirely extinct. In a beautiful archipelago, this island is exceptionally lovely and, as it has been less visited by entomologists than most of the others, it offers excellent chances for discoveries. The lowlands, however, have been mainly given over to pineapple and sugarcane, and it is necessary to search in the moist forests of the mountain area for the characteristic native insect fauna.

My visit to Kauai resulted in some conchological discoveries,[2] but nothing of importance in entomology, because I could not reach the heights. I was very fortunate in being able to join the excursion of the Trail and Mountain

[1]The introduction to the *Fauna Hawaiiensis* (Vol. I, Part VI), by Dr. R. C. Perkins, is a work of classic rank, discussing the various zoölogical problems presented by the islands with a thoroughness and breadth of knowledge which has perhaps never been equalled in a work of this type.

[2]See *Nautilus*, Jan. 1925.

Trail and Mountain Club on the Island of Kauai. The truck was stuck in the mud and was pulled out by the caterpillar tractor

Club of Honolulu, led by Mr. R. J. Baker, the photographer. The group of sixteen men and women occupied a two-ton truck, which traveled rapidly over the asphalt roads. We stopped at various points, walking up into the forest or along the shore, and camped on the beach where the bathing was good. After spending a night at the Barking Sands we started along an unpaved road, to regain the high road to Waimea. Before we had gone far it began to rain violently, and in a little while the surface of the powdery road was covered by an inch or so of sticky mud. The heavy truck refused to go, its wheels revolving without any resulting progress. Once or twice we nearly went into the ditch. The whole company labored, pushing and putting various things under the wheels, all the time in pouring rain. In spite of our lack of success, the greatest cheerfulness, one might almost say hilarity, prevailed. Presently some one saw a caterpillar tractor in a near-by field and this machine, constructed like an army tank, readily pulled us out. Once on the paved road, we were soon in Waimea, where there was no place to camp except on the platform at the foot of the pier, which was at any rate roofed over and so protected from the rain. Being wet to the skin and without other clothes, we executed all the dances and physical exercises we could think of, while rows of Japanese children viewed the spectacle with polite amazement. As this was the first time the Trail and Mountain Club had thus visited Kauai, the children had probably never before seen women in hiking costume, but they restrained their emotions as children of our race would never have done. They would not even take candy until their elders gave consent. The trip was celebrated by a ballad, beginning thus:

Oh, we're camping on Kauai,
As the treasured moments fly,
And we live once more as life was meant to be,
For we've left the teeming city,
And to those we give our pity
Who never camped betwixt the palms upon
the beach and sea.

All of which may not be, strictly speaking, entomology, but that does not matter. And for a token that I was really there, I have before me a row of splendid flies, shining green and purple, captured at Waimea. Do not regard them with scorn, because they are the introduced *Volucella obesa*, widespread over the earth. Many years ago, my wife took exactly the same species at Quirigua, Guatemala.

On the other side of the globe, far out in the Atlantic from the coast of northern Africa, are the Madeira Islands. They consist of Madeira proper, Porto Santo, the Desertas, and a number of islets. Like the Hawaiian Islands, they are volcanic and, like them, they seem never to have been united with any continent. The entomologist whose "footprints" we see on all sides here is T. Vernon Wollaston. I have his book, *Coleoptera Atlantidum, being an enumeration of the Coleopterous Insects of the Madeiras, Salvages, and Canaries* (1865), one of the great contributions to the philosophy of entomology. My copy possesses added interest from containing the book-plate of Frederick Ducane Godman, a name so well known to us in connection with the natural history of Central America. Wollaston's specimens may be seen in the British Museum and at Oxford. My wife and I visited the Madeiras in the winter of 1920-21. Living in Funchal, the one large town, we found a fauna consisting largely of species introduced during the long period of human occupation. It is easy, under such circumstances, to mistake wholly the true character of the fauna. Thus the Madeira Diptera which were identified by Becker are essentially of European type, common flies to be found almost anywhere on that continent. In this they strongly contrast with the beetles, a very large proportion of which are endemic. But the beetles were collected by Wollaston with great industry in every wild place he could reach, while almost all of the flies came from Funchal or the immediate vicinity. It still remains for someone to explore the out-of-the-way spots, and obtain the peculiar Diptera which very possibly occur there. Some of the smaller crane-flies, or Tipulidæ, may be especially worth while. Thus the genus *Dicranomyia* is not in the Becker list, but I collected *D. canariensis* of Becker at Funchal, December 29 and 30; and at about 3000 feet altitude on the Pico do Serrado my wife obtained Wollaston's *D. maderensis*, along with the interesting little *Dixa puberula* Loew. Mosquitoes from Funchal were ordinary species, probably introduced (*Culex pipiens, C. tipuliformis, Theobaldia longiareolata*), but the buffalo-gnat (collected by our young friend Fred Jones) proved to be *Simulium ornatum nitidifrons* Edwards, recently described. We found one species of moth-fly, *Pericoma meridionalis* Eaton, not listed by Becker. All these flies were determined for us by Mr. F. W. Edwards of the British Museum. Small gnats of the genera *Chironomus*, *Culicoides*, and *Forcipomyia* have not yet been definitely identified. Among the larger flies at Funchal was *Stomatorrhina lunata*, with beautifully banded eyes. These details are not in themselves of much interest to those unfamiliar with the insects but they show that even a small amount of collecting produces results of scientific value. Perhaps the most interesting capture in Funchal was that of a pretty little moth, new to science, brought to us by Fred Jones, the son

Porto Santo with the Ilheo de Cima in the distance. Date palms in the foreground

of our host at the hotel. It has been named *Cosymbia lilacinipes*.[1]

In Madeira we went to Machico, Canical, and over the pass to Porto da Cruz. But by far the most interesting expedition was to Porto Santo, the island where Columbus once lived, and from which he looked across the ocean, wondering what might be on the other side. The house he occupied was only a few steps from the one which we occupied in Villa Baleira. There was no regular boat to Porto Santo, and we therefore took passage in a large fishing vessel which had come to Funchal for commercial purposes. Late at night we put out of Funchal harbor, watching the bright lights receding as we rounded the point to the east. They gave us the cabin de luxe, namely the row-boat hauled up on the deck, and in this we rested, listening to the musical chant of the sailors as they plied the long oars. The following day we came safely to Porto Santo, and were carried through the surf by strong arms, and deposited on the sandy shore. The island is very small, and can be readily explored on foot. The greatest interest, however, centers in the outlying islets, some of them no larger than a big building, yet supporting peculiar snails and beetles. Thus on the Ilheo de Cima, on which stands the lighthouse, the specimens of the ground beetle *Scarites abbreviatus* are all of gigantic size, constituting a well-marked race which I named *cimensis*.[2] Other peculiar beetles were found on other islets, and unquestionably more remain to be found. Most remote was the small Nordeste, where landing was difficult as the boat rose and fell with the waves, giving us but an instant for a successful leap to the rugged lava rock. Here we got a new beetle, and snails which live nowhere else, one of

[1] *Proc. Entom. Soc. Washington*, XXV. 163. (1923.) With regard to the Becker Diptera I did not have access to the published account, but derived my information from the collection identified by Becker, in the Seminario at Funchal.

[2] *Proc. Ent. Soc. London* for 1921. p. lviii. For a general account of I. de Cima and its peculiar snails, see NATURAL HISTORY, May–June 1922, p. 268. For the general problems connected with Madeira Island beetles, see *Ann. Mag. Nat. Hist.*, June, 1923, and for Lepidoptera, *Entomologist*, Nov. 1923.

Villa Baleira, Porto Santo

them of exceptional beauty. The visit suggested the following lines:

NORDESTE

Islet girt by tossing seas,
Facing ev'ry wind that blows,
Raging storm or gentle breeze,
Here the orange *Lotus*[1] grows.

Here alone in all the earth,
Some things of beauty do abide,
And on this lonely rock had birth
And never yet have crossed the tide.

Who can say what rugged shore,
What heart with brambles overgrown,
May give to those who will explore,
Some treasures all its own.

When we finally had left the Madeiras and sat down to supper in the dusk of the evening, Nordeste came in view through a porthole opposite, like a picture in a frame. It was our last sight of the islands.

The Japanese islands differ in almost every respect from the Madeiras or the Hawaiian group. They are of "continental" type; that is, they represent a partially submerged area which was once connected with the Asiatic mainland. The Japan sea, between the main island of Japan and Siberia, is very deep, but to the north and south there is comparatively shallow water. Indeed, the Gulf of Tartary, separating Sachalin Island from the Amur region to the west has every appearance of being an old river valley, the river flowing south into what is now the Japan Sea. Northward, one may still go from Japan to the mainland, crossing only narrow straits; those of Tsugaru, La Perouse, and the very narrow head of the Gulf of Tartary. Furthermore, the Kurile Islands form stepping stones from Japan to Kamchatka, as we all know from following on the map the recent flight of the American aviators. To the naturalist the biota of Japan is full of interest. What proportion of the types observed came in from the north, or are related to those of the northern mainland? How much is there of the fauna of China and Korea? How much evolution has taken place within the Japanese area? What has

[1]*Lotus floridus* (Lowe). See *Torreya*, XXII, p. 7 (1922).

been the influence of climate, what of available migration routes? My own visit to Japan, in 1923,[1] was so brief that it was not possible to make any extended observations. At Tsuruga, on the west coast, it was very easy to notice the mingling of northern and southern types of life, the latter apparently predominating. Thus the large snails, superficially similar to those of Siberia, differ anatomically, and are really of southern origin. Some of the plants are closely related to Chinese species. The sweet-scented tree, *Hovenia dulcis*, so attractive to bumble-bees, has a wide range on the mainland, even to the Himalayas. On the other hand, the species of bumble-bees, and some of the butterflies, have northern and northwestern affinities. The famous Japanese beetle (*Popillia*), which has caused so much trouble since its undesired arrival in the state of New Jersey, was found at Tsuruga on roadside weeds, doing no harm. It is doubtless controlled by its natural enemies. We stopped at Gifu to visit the celebrated entomologist Yasushi Nawa, who is now bedridden and unable to continue active work. In his museum we saw many Japanese insects, and were especially interested in a fine collection of fossil insects, apparently of Tertiary age. When these are worked up, they will undoubtedly throw much light on problems concerning the origin of the Japanese fauna. A conspicuous feature in Japan is the abundance of cicadas, which are caught by the children and kept in little cages. We heard at Tsuruga the one which Dr. D. S. Jordan refers to, as having a voice so like a bird that he was deceived. Japan is a beautiful country, and we found the people very friendly. The visiting entomologist is sure to reap a rich harvest, and although very much has been written on Japanese insects, there is still plenty to do.

Collecting insects at Tsuruga, Japan, June, 1923

[1] For details see *Scientific Monthly*, April 1925.

The Adventures of Ctenucha

A MEADOW CATERPILLAR

By EDITH M. PATCH
Department of Entomology, University of Maine

CHILDREN, here is a story written especially for you by one of the best-known of all women entomologists. But, although an "-ologist," Miss Patch is one of you, as you know if you have read her "Hexapod Stories" or her "Bird Stories." We hope you, no matter how old or how young you are, will like this story as much as we do and we will try to have Ctenucha on our Nature Trails next summer. Perhaps you, too, can find and keep one for a pet.—THE EDITOR.

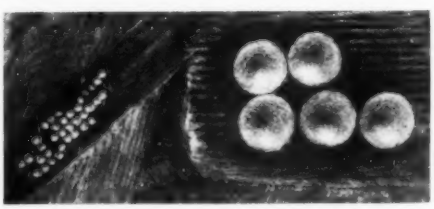
CTENUCHA had her first adventure while she was young. She was, indeed, so very young that she was still living inside an eggshell when things began to happen.

The eggshell which was her first home was shaped like a ball, except that one side was flat. The flat side was fastened to a blade of grass. The egg was so small that it would have taken more than twenty like it, resting side by side, to make a row an inch long. There were nearly two hundred similar eggs in rows on grass blades near the egg in which she lived. Inside of each of these eggs was a brother or sister of Ctenucha's.

After she had lived for ten days in the egg, it changed color. It had been yellow at first, as yellow as honey. On the eleventh day the egg looked gray. The shell itself was not gray. It was really as white as a pearl. The egg looked gray because something inside had turned dark and was pressing against the shell. The dark thing was Ctenucha's head.

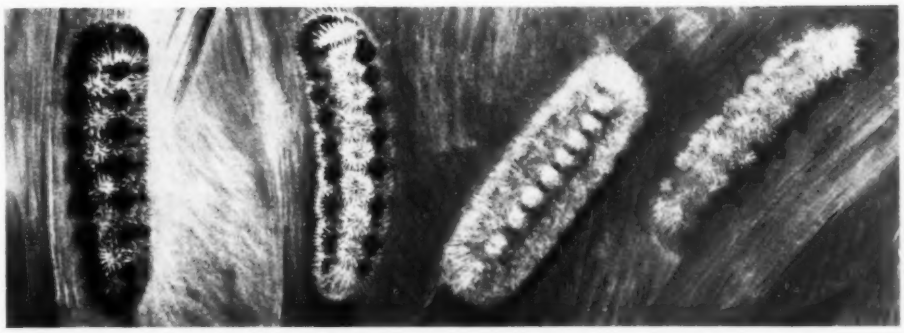
The next day the dark head showed even more plainly through the thin shell. Little Ctenucha was moving her jaws in a hungry way. It is not unpleasant to be hungry if there is good food to eat, and the wee caterpillar liked eggshell. She scraped and scraped against the shell with her jaws for hours until at last she made a hole in it. There was no reason then why she could not have crept through the hole, except that she was so hungry for eggshell that she ate her way out instead of creeping out. So she stayed and ate until she was no longer inside the shell but most of the shell was inside of her.

That was Ctenucha's first adventure, eating her way into the world of sunshine. You need not be surprised to learn that a creature who began life so strangely should do other queer things from time to time. That is, they seem odd to us, though all Ctenucha really did was to live a natural caterpillar life. If you wish to see for yourself how she acted, you need only find an egg like hers and watch from the time the baby insect eats its eggshell until its last adventure.



Eggs (much enlarged, on the right) of Ctenucha. Each caterpillar eats the shell of the egg from which it hatched

Ctenucha had sixteen feet. Three pairs of them were on jointed legs near her head. These she did not use much



Various patterns in the last coats worn by Ctenucha caterpillars

in walking. She held them somewhat like hands at each side of her food when she was eating. She crept with the other five pairs, soft clinging ones with which she could hold firmly to the thin edge of grass.

She did not need to learn to creep, and it was well for her that she could travel at once; for, soon after she had finished her breakfast of eggshell, she was ready for dinner. Perhaps it was the smell of growing grass that made her hungry, for she crept about the plant until she came to a tender leaf. Then she began to nibble. From the moment she first tasted grass, she seemed contented with that sort of food; and, as long as she was a caterpillar, she sought no other kind. Her journeys for meals took her no farther than from one grass plant to another, and some days she ate so steadily that it would be hard to tell when her breakfast left off and her supper began.

After eating busily for several days, she stopped to rest. She was forced to stop because she had grown so fast that her skin could not hold any more body. When she was in that sort of fix, she pulled herself out of her skin, but that took time. She rested quietly until the tight skin ripped back of her head. Then she crept out of it, leaving the skin, old skull and all, lying on the grass. She did not need it any longer because a new coat of skin had grown to take its place. She could now again eat grass until this new coat, in its turn becoming too tight, would be discarded.

That is the way Ctenucha passed the days until fall—eating, growing, resting, molting. Every time she molted she had a different-looking skin. She changed her coat for a bigger and prettier one each time. Her first little coat had been whitish yellow with tiny black dots from which grew a few dark hairs. Each new coat had more hairs than the one before. The garment she was wearing when cold weather came had a row of black hairs down the middle of the back with a stripe of yellow hairs on each side.

Ctenucha's home was in a northern part of the country where, during the cold winter, the grass stops growing and the ground is covered deeply with snow. Some animals in that part of the world must live all winter without eating. Bats and bears and woodchucks and skunks and frogs and earthworms and many insects can do this. All these animals that live during the winter without eating, manage in much the same way. Each seeks a comfortable place and goes to sleep. That is what Ctenucha did. Her

winter's adventure was a nap. But her sleep was not so sound as that of some of the other animals; and when it was warm enough, as perhaps during a January thaw, she wakened and went for a walk. A party of boys and girls who were tramping across the fields on their snowshoes when the weather was mild saw a black-and-yellow creature hurrying over the snow, and they called it a "winter caterpillar" and wondered where it was going.

After fasting all winter, Ctenucha was very hungry in the spring and, when the grass began to grow, she ate greedily. The coat in which she had slept was no longer pretty. The yellow hairs had faded until they were the color of old straw, and the black tufts were dingy. She could not change this garment for a better one until she was plump enough to molt, but she ate so many tender grass blades that by the middle of April she could not swallow another mouthful.

She crept to a bit of stubble and spun a thin mat of silk upon the dry stem. She tangled the hooks of her ten creeping feet among the threads of the mat and rested quietly with her head down. After a while she pulled her head back out of her old skull and then she looked as if she had a swollen neck. The new head inside the old skin pressed so hard that at last the skin tore at the "collar," and Ctenucha's head popped through the hole. The six jointed legs and the ten creeping feet were all pulled out of their old stockings and Ctenucha crept forth like a new creature. She left her old coat lying on her molting-mat on the stubble and went in search of fresh grass.

Before she molted in the spring, her coat, as you may remember, had a row of black tufts down the middle of the back. There were more than one thousand caterpillars of the same kind in the meadow where she lived, and every one of them wore a winter coat like hers, with black tufts in a row down the back. All these thousand and more caterpillars molted their winter coats in the spring, after they had been feeding on grass for a while. Some of the new spring coats had black tufts on the back and some of them had white tufts. Of course, the caterpillars could not choose which color of tufts they would have. Each one had the kind that grew, just as you have dark hair or light hair, without choosing.

Ctenucha's spring coat had a row of white tufts bordered on each side by a soft yellow stripe. Her ten creeping feet were red, not bright red, but a soft dark shade. Her head was the same pretty color, except her face, which was black. If, some spring day, you chance to meet a creature like her, with a black and red skin and a yellow and white coat, you will be glad to see so good-looking a caterpillar.

Fine as the new spring coat was, it did not last long; for one day Ctenucha pulled the hair out of it, and then she was as queer as a hen without any feathers.

The day she pulled out her hair was the time of one of her greatest adventures—the day she made her cocoon. I like to remember that day, because she wove a basket-like cocoon without making one mistake; although it was the first cocoon she had spun and there was no one to show her how to do it.

After Ctenucha had taken the last bite of grass she was ever to swallow, she sought a piece of bent stubble and crept to the under side of it. Clinging to the dry stem, back down, she began to spin. Perhaps you know that a

caterpillar has silk glands in its body where liquid silk is made. When a caterpillar is ready to spin, the silk drools out of an opening through the lower lip and, when it touches the air, it is stiffened into a thread.

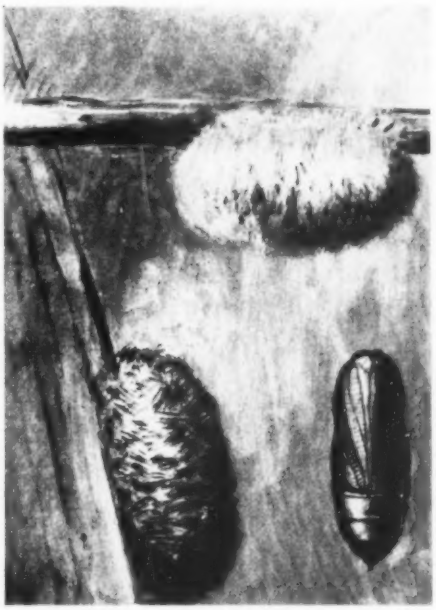
Ctenucha had spun silk before. She had made a mat of silk in which to tangle the hooks of her creeping feet while she molted. The molting-mat held her old skin steady while she pulled herself out of it. But to make silk enough to cover her whole body was quite a different matter.

Against the lower edge of the stubble she first spun a strip of silk about as long as she was herself. She clung to this with her creeping feet while she made the rest of her cocoon. When she was spinning, she used her jointed feet somewhat like little hands to guide the thread and to help shape the cocoon. She wove the edges down at each side and each end until they nearly met at the middle and then she joined the edges.

Some caterpillars weave their cocoons entirely of silk, but Ctenucha did not. She used hair also, making a kind of haircloth cocoon; and the hair that she used she pulled out of her coat. First she would add some silk to the edge of the cocoon, and then she would reach her head back and grasp a mouthful of hair close to her skin and pull it out. It came out quickly. I do not think the jerk hurt her. She would tuck the mouthful of hair endwise into the silk she had just spun, and then she would spin more silk in which to tuck the next mouthful of hair.

She worked without wasting any time or any motions. When she was spinning the left side of the cocoon, she reached to her left side and pulled hair from that part of her coat. By pulling hair that was nearest the place she was spinning, she saved time and strength. She did not weave in a quick nervous way. She wove slowly and steadily and she did not stop to rest until the cocoon was quite done.

When Ctenucha's cocoon was finished, her body was stripped of its hair. She had just enough hair for the cloth



Haircloth cocoons, each woven by a young Ctenucha using silk made by itself and its own hairs. Also a pupa, which is the stage between caterpillar and adult moth

of her cocoon. Do you not think that it is wonderful that she could weave that perfect little basket-like cocoon the first time she tried? No one to show her how! Not stopping until it was finished! Measuring out her hair so that there was enough for the cocoon and none to spare!

It seems fitting that she should have a marvelous cocoon, for remarkable things happened in it. In fact, two of her best adventures took place inside the cocoon.

After her weaving was over, Ctenucha lay quivering with the changes that were taking place in her body. After a day or so of waiting, her caterpillar skin ripped down the middle of the back far enough so that she could squirm out of it. She looked queer while she was doing this, for she

A full-grown Ctenucha, now an adult moth with fore wings like "changeable silk," a peacock-blue body, and orange head and shoulders

was not a caterpillar any longer. She was, instead, a soft wriggling object with six legs (much longer than any she had had before), four wing-pads that flopped a very little, a long straight quivering tongue, and two feelers. Legs, wing-pads, tongue, and feelers all moved feebly for a minute or two and then they were glued fast to her body by the fluid that had helped loosen the old caterpillar skin and then hardened in the air inside of the cocoon.

Ctenucha was a caterpillar no longer. She had changed into a pupa. When she first became a pupa, she was bright red with a row of cream-colored spots down her back, but she soon turned dark brown all over and was so shiny that she looked as if she were covered with varnish. At the tail end of the pupa there were some tiny hooks that caught into the silk of the cocoon.

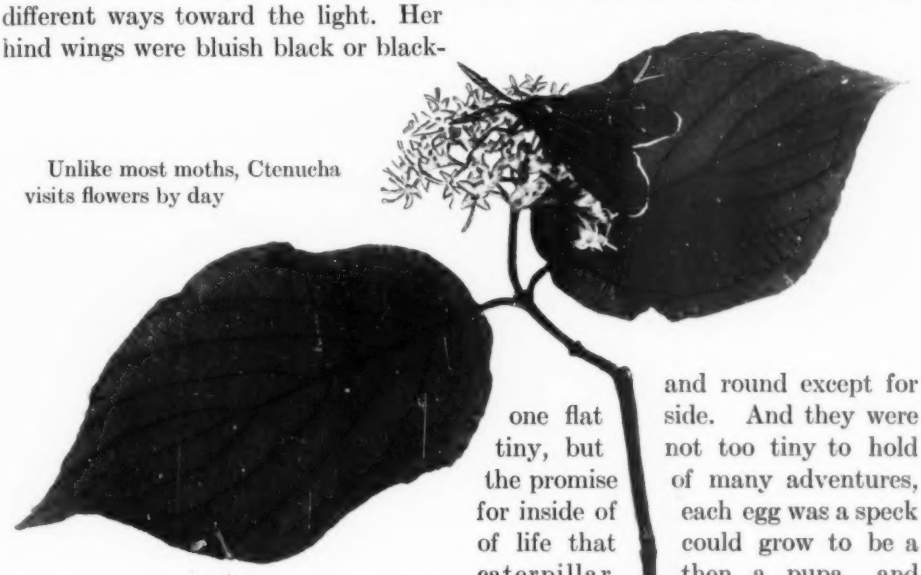
First she had been an egg, and then a caterpillar, and then a pupa. What would she be next? Next she would be a moth; but not until she had lain waiting, as a pupa, for sixteen days. Then the shiny brown skin cracked open and she came out of it. The hooks on the end of the pupa held the skin steady while she pulled herself free. She pushed her way through one end of the cocoon and waited for her wings to expand and grow strong.

Ctenucha was at last a moth, a full-grown insect with wings; and the adventures that lay ahead of her were quite different from those of her caterpillar days. I cannot tell you whether she had a better time after she came out of the cocoon than she did before she wove herself inside of it. I can only say that she had acted as if she were a contented caterpillar while she was nibbling her first breakfast of eggshell, while she was munching her many dinners of grass, and while she was weaving her one wonderful cocoon. After she became a moth, she still acted as if it gave her pleasure to do what things she could.

Most kinds of moths fly only at night, but Ctenucha flew during the sunlight hours. She visited clover, spreading dogbane, meadow sweet, viburnum, and other flowers. She carried her long tongue coiled tight like a watch spring while she was flying; but when she reached a flower, she straightened her tongue and put the tip of it into the tube of the blossom and sipped the sweet nectar she found there. She drank dew, too, feeling along the grass blades with the tip of her tongue and sipping the dewdrop as she did nectar. Sometimes she flew to bushes and trees where there were colonies of aphids and drank the sweet liquid, called honeydew, that aphids drop from their bodies.

It was not easy to see her colors when she was flying, but while she was feeding at a flower it was possible to

look closely. Her fore wings were a queer color. Sometimes they looked rusty black or brown and sometimes bronze or purple or green. Like "changeable silk" their colors were different when they were turned in different ways toward the light. Her hind wings were bluish black or black-



Unlike most moths, Ctenucha visits flowers by day

ish blue. All four of her wings were narrowly edged with white. Her body was glistening peacock blue with a dash of bright orange color just behind her head. Her head was orange-colored, too, except the middle of her face which was blue, and her feelers and mouth parts which were black.

However pleasant she may have found the flowers, she did not spend all her time among them. She had another adventure of much importance. There were her eggs, nearly two hundred of them, that needed to be glued to grass blades. Even the sweet taste of nectar or honeydew did not tempt her to neglect her eggs. She put them in rows, close together, sometimes more than twenty on a single leaf of grass. Like the one in which she herself had started life, they were yellow as honey and round except for one flat side. And they were tiny, but not too tiny to hold the promise of many adventures, for inside of each egg was a speck of life that could grow to be a caterpillar, then a pupa, and then a moth.

All the time that I have been telling you about the adventures of Ctenucha, I have been wishing that you might have an adventure of your own. I have been wishing that you might see an egg like one of Ctenucha's hatch; or notice such a caterpillar at molting time; or watch one weaving a cocoon; or find a moth whose body is glistening blue trimmed with bright orange, and whose wings have queer changing colors. Perhaps my wish for your adventure may come true. Wishes often do.

Insect Sounds

By Frank E. Lutz

THE first part of this article was delivered as one of the American Museum's radio broadcasts. That fact explains the references to receivers and transmitters, also the dashes that represent the making of sounds. The second part taking up the same subject from a different angle and for a quite different audience was given subsequently at a meeting of the Entomological Society of America in joint session with the Ecological Society of America.

I

When I was asked, more than a month ago, to hand in a title for this evening's talk I played safe and said I would speak on "Some Interesting Habits of Insects." That gave me a very wide field from which to choose a very few remarks.

I live in one of New York's suburbs and there I have a small yard seventy-five feet front and two hundred feet deep. In that yard I have personally observed more than 700 different kinds of insects. Now, if 700 different kinds of birds came into your back yard and if each of these 700 different kinds of birds had some interesting habit or some curious turn in its life-history, you would marvel at the opportunity lying at your very door for the study of nature. That is the case with those who know something about the ways of insects. Samples of some of the species that live in or that have visited my back yard are on exhibition at the American Museum of Natural History. It is not so easy for us to exhibit the habits of these interesting creatures, but I will try to suggest some of them tonight and I invite you to become even better acquainted than you are with God's out-of-doors, where these habits are on exhibition day and night, winter and summer.

Recently the Westinghouse Company announced the invention of a new type of microphone intended primarily for use in broadcasting programs by radio, but the men in the Research Department of that progressive company saw the possiblity of using it to study the sometimes faint sounds made by insects. Furthermore, insects have antennæ, and some students, probably influenced by the fact that your aërial and mine are called antennæ, have suggested that insects send and receive messages by a method somewhat similar to radio. Personally, I doubt this, but I have lived so long in an open-minded, scientific atmosphere, that I am willing to admit the possibility of any idea that has not been disproved. At any rate, I think that a radio audience will be interested in the sound-making habits of insects, and so I have selected that as my special topic for this evening.

There is scarcely a grass-plot in the United States that does not contain crickets. At certain seasons of the year some of these crickets become musical and the air is filled with chirps, usually cheerful but occasionally sounding sad and lonesome. How do the crickets chirp and why do some of them chirp, while others are silent?

I must tell you first that the female cricket has a long, slim, needle-like affair at the end of her body and that with this she places her eggs under the

surface of the ground. The young cricket as it leaves its underground nest looks much like an adult cricket except that it is very small and has no wings. Like Mr. Finney's turnip this cricket "grows and it grows." From time to time as it grows it sheds its skin but it does not get wings until the last molt, when it is fully grown.

The reason for explaining all of this is that crickets chirp by rubbing their front wings together. Near the front of each front wing of a male cricket (but not of a female) is an enlarged rib or brace. On the under side of this rib is a series of small teeth. Then, on the upper side of each front wing is a small rough spot so placed that when the wings are rubbed together the teeth on the under side of one wing scrape on the rough spot that is on the upper side of the other. If your rheostats and dials can spare you for a moment, stretch your hands out in front of you with the *palms up*. Now, let the knuckles of your right hand represent the file on the underside of a cricket's front wing and rub these knuckles on the callouses at the bases of the fingers of your left hand. That is the idea but, of course, there is no sound produced because your hands are not thin membranes like the cricket's wings. In the case of the cricket this rubbing of a filelike structure on a rough spot sets both wings to vibrating very rapidly, probably at a rate of not far from 15,000 shakes per second. This rapid vibration of the wings up and down as the male cricket rubs them against each other from side to side sets the air to vibrating in waves of such a character and frequency that our ears recognize a shrill sound or chirp. I have here a file and a thin piece of tin and I am going to rub one against the other (---). The tone is not the tone of a cricket's chirp because the tin has not the same qualities as a cricket's wing, but the sound is produced in exactly the same way. Katydids are near relatives of crickets and play the same sort of instrument. Their favorite selection is something like this (---). The effect of this rapid vibration of the cricket's or of the katydid's wings seems to be exactly the same as that caused when electrical impulses rapidly vibrate the diaphragm of our telephone receivers. A difference is that, so far as we know, there is nothing electrical about either the cricket's chirp or the katydid's song. They are purely mechanical.

Now, an interesting point is that only the male cricket has this apparatus and, of course, not even the male has it until it is adult and has fully developed wings. Young crickets are "seen but not heard" because they have no wings and female crickets keep quiet, even when they are adult, because they cannot do otherwise, for their wings have no sound-producing attachments. An old Greek poet whose wife was probably different from mine knew about the prevailing silence of female insects and wrote concerning one kind:

> Happy are cicadas' lives
> For they all have voiceless wives.

So much for the sound-production by crickets, their transmitters. What are their receivers like? You receive sounds by feeling the vibrations of very small diaphragms, one located on each side of your head. I do not mean the diaphragms of your telephone head-set, if you are using one, for, as far as you personally are concerned, the phones are still a part of the transmitting system. I mean your ears and more particularly your ear-drums. Apparently crickets also have sound-receiving diaphragms or ear-drums but they are on the front legs and not on the head.

The next time you see a cricket, catch it. Look on the second main joint of either of the front legs and you ought to be able to detect a small white spot. If you examine this spot with a microscope, you will see that it is really a small diaphragm set into the leg. It is supposed to be an ear and, if it really is an ear, both males and females can hear. We do not know how much they can hear but presumably they can at least hear other crickets chirping.

Tree-crickets, katydids, and all of the grasshopper tribe that, like katydids, have very long antennæ, make sounds in the same way that ordinary crickets do, and they all have much the same sort of receiving apparatus. On the other hand, the grasshoppers that we commonly see, those having short antennæ, are different. Some of them make no sounds that we can hear and apparently have no sound-producing apparatus. Possibly the new microphone will reveal sounds made by them and then we will try to discover how these to us inaudible sounds are made. Others of these short-horned grasshoppers make rasping sounds by rubbing their hind legs against their front wings. Still others make loud sounds by rattling their wings together as they fly. I have here a wooden contraption that we used to call a "razzle-dazzle" or "policeman's rattle." As you twirl it, two thin pieces slap against large cogs and make the noise you will hear shortly; but, first, lift off your ear-phones if you are using much amplification. (---) That noise was made by use of exactly the same mechanical principle that certain grasshoppers employ. When I bought this "razzle-dazzle" last week, a man in the shop remarked that I must be going to a wedding. I was not, but the man's remark was curiously close to a scientific teaching. The grasshoppers that make sounds in this way are, we think, hoping to go to weddings and they plan to be the bridegrooms. The prospective bride is sitting quietly in the grass as her lover flutters in the air above her and rattles his castanets.

A peculiar thing about the receiving apparatus of these short-horned grasshoppers is that the receiving diaphragms or ear-drums are not on the legs as they are in their close relatives, the crickets and long-horned grasshoppers, but on the abdomen, one on each side near the base.

Cicadas (the harvest-flies, seventeen-year locusts, and the like) make sounds that may sometimes be heard by us for a mile or more. The transmitting apparatus in this case is of still another type. There is a pair of transmitting diaphragms on the abdomen at about the same place as the receiving diaphragms of the short-horned grasshoppers. A tendon and muscle is attached to this transmitting diaphragm and by means of these it is pulled in and then suddenly released. As it snaps back, it makes a click. I have here a little tin affair that lecturers often use to signal for a new lantern slide. It is sometimes miscalled a "cricket" but it should be called a "cicada." The piece of tin is bent somewhat and, as I push, it bends the other way with a "click" (---). Then, when I let go, it snaps back and makes another "click" (---). The cicada does this so rapidly that the clicks merge one into another so as to make a sort of a buzz or a roar. The best I can do is something like this (---). It might be mentioned, incidentally, and in accord with the Greek poet, that only the male cicadas make this sound.

It is altogether likely that cicadas would not go to all this trouble in producing sounds if other cicadas could not hear them, but I do not know what their receiving apparatus, if they have one, is like.

It is said that mosquitoes receive sounds by means of their antennæ in a very interesting way. We all know to our sorrow the hum made by a mosquito. It is the hum made by a female mosquito that is of most interest to human beings because only the female bites. Now, the antennæ of all mosquitoes are feather-like or plumed antennæ, but especially so in the case of the males. It is said that the hairs which make up these plumes can be set into rapid vibration by sounding on a violin the same note that is made by the female mosquito. I have not seen this happen myself but I hope to try it out this summer. It is probably true, because we know that a tuning fork or a piano string can be set into vibration by sounding the note for which it is tuned. If the hairs on a male mosquito's antennæ are tuned to vibrate at a note corresponding to the female's hum, he can doubtless feel the vibrations and so hear the hum just as we feel vibrations of our ear-drum and call those sensations hearing. (In that case the mosquito does employ antennæ in its receiving apparatus but there seems to be nothing electrical about it nor anything that corresponds to radio.) Far be it from me to suggest that there is any connection between the facts that female mosquitoes are not voiceless and do bite.

Although there is much more that could be said about the transmission and reception of sounds by insects, there is nothing that is much more definite than what I have told you. Do ants and other insects actually communicate by means of sounds which we cannot hear? No one knows but some of us are trying to find out.

II

Probably the first definite sounds made by land-animals on this earth were made by insects. Before ever birds sang or even frogs croaked, insects had developed a chitinous covering, the segments of which, rubbing together, produced sound-waves. Whether these sound-waves were audible in the sense that there were organisms with nervous mechanisms attuned to them might be the subject of an interesting speculation. Crickets and katydids belong to the order Orthoptera, and orthopteroid insects were abundant in the Carboniferous period. In the fields and forests of those days, or possibly earlier, was started "the poetry of earth" that "is never dead."

Judged by human ears, the best insect-musicians of today belong to rather primitive orders. The more advanced groups, such as ants, bees, wasps, flies, and butterflies, make no sounds that we can hear or else, at most, what seem to us to be nothing more than faint squeaks, buzzes, hums, or clicks. However, it is entirely probable—indeed, practically certain—that insect-sounds are not made for the purpose of being heard by human ears. Whether the insects themselves hear these sounds is the important question and one that has not been—possibly cannot be—determined beyond all doubt.

In this connection it should be remembered that, in man's affairs at least, many sounds are made without intention and even contrary to desire—for examples, sneezing and snoring. No part of the success of a certain

popular kind of automobile is due to the various and often loud noises emitted by the machine in action. Using an illustration more applicable to the present subject, the armor of the knights of old creaked and rattled as they moved. Their fellows were able to hear these sounds and reacted to them. A rough spot in a particular joint increased the sound made by the moving of that joint. Now, if the armor-maker purposely designed these joints to creak or if the wearer purposely creaked his armor, even if for no other motive than to tickle his pride (as has been the case with wearers of squeaking shoes), then the creaking of the joint had a significance analogous to that usually claimed for certain sounds made by insects—there was an adaptation of structure to sound-production. But, considering now the sounds made by insects, if they are merely incidental to friction between parts of the body, analogous to unintentional squeaks and rattles of knightly armor, then those sounds have no biological significance, except as they may betray the insect to its enemies.

Man has made many guesses as to the significance of insect sounds, but there are two points in this and similar connections to be kept ever and strongly in mind. One is that in science a good guess is very useful as a starting point but exceedingly harmful if, forgetting that it is after all only a guess, we accept it as a proved fact. The second point is that it is dangerous to judge the actions of lower animals by human standards. Was it not Paul who said that, when he was a child, he thought and acted as a child but, when he became a man, he put away childish things? Well, a man is much farther removed from the lower animals than he is from a child and, except in slang, he is not and never was a bug. Bugs were not even in his ancestral line.

There is much joy to be had in giving free rein to our imagination and, on the other hand, man prides himself on being "practical," meaning that everything must be of some use or be abandoned. The combination of these two human traits has resulted in most ingenious stretches of human imagination to find the "practical" reason for everything that we see or hear in this world.

Prior to the Fifties of the last century scores of books were written to show that God was "practical" and that everything was made by Him to serve some definite, very useful purpose. If no purpose could be imagined, the failure was said to be due to the fact that the ways of God were inscrutable and past finding out. Since the Sixties, thousands of books and papers have been written to show that Natural Selection is eminently "practical" and that everything is forced by it under penalty of extermination to serve some definite and very useful purpose. If no purpose can be imagined, the failure is said to be due solely to our present lack of knowledge but the purpose is not past finding out. We even have a name for this branch of biology. It is ecology, the science that gives a reason for everything.

Lack of knowledge is, I am glad to say, frequently a fact. It is the unknown that makes biology more interesting than arithmetic. Of the many Latin mottoes I have seen—why do they so often put good mottoes in poor Latin?—one of the best for a biologist is that which, being translated, reads: "We are ignorant; let us work under this banner.' Let us work under this banner but let us not

dodge under it or use it for the purpose of tying together the pieces of a broken theory.

As to the universal practicality of all creation, I hope that the swinging pendulum of human thought may speedily bring us to a point where the slogan "Whatever is, is good" will be changed to the more moderate one of "Whatever is, is not bad." It is my firm belief that many striking characters and characteristics of animals and plants are of no use to their possessors or to any other creature. As I have said elsewhere, they seem to me to be much like the figures in a kaleidoscope, definite and doubtless due to some internal mechanism but not serving any special purpose.

However, we must be on our guard against carrying any belief too far and it would be absurd to say that no special characteristic of any animal or plant is useful to it; also, while some insect sounds appear to have no biological significance, others do appear to have a very decided significance. In that case, we are brought to the threshold of the real problem, really a double problem: How and why has the ability to make these particular sounds arisen?

Most of the sounds made by vertebrate animals are vocal, that is, they are due to the combined action of lungs and larynx. Insects have no lungs, strictly speaking, and most of the sounds which they make may, for the want of a better term, be called mechanical.

The simplest of these sounds is the striking together of two parts of the body. Certain bees, such as the domesticated honey-bee, and certain flies, such as the Syrphidæ, make a shrill noise when they are captured. For years this sound was supposed to be a vocal one. Instead of lungs, insects have air-tubes running throughout their bodies and opening to the outside as a series of small holes. These openings are sometimes provided with membranous flaps. All of these structures were carefully dissected and beautifully pictured by skilled anatomists, the conclusion being that air, forced out of the tubes, set the flaps into vibration and made the noise. This conclusion became firmly established by ingenious experimentalists, who did many things, including cutting off the wings and noting that this did not stop the sound. Then came one of those troublesome fellows who upset traditions. He pulled out the wings instead of merely cutting them off and then the sound stopped. He did other things also and now we know that this shrill note is caused simply by the bases of the wings beating vigorously against the body.

This sound has been very useful to the proponents of the mimicry hypothesis. According to theory, bees make it to warn their captors that stinging is about to start, a most sportsmanlike trait; flies, on the other hand, make this sound to fool their captors into thinking that stinging is about to start, and that trait is commendable only on the grounds of self-preservation, for flies have no sting. As a matter of fact, spiders are the flies' worst enemies and spiders calmly tie up and kill bee and fly alike, clearly paying no attention to the noise and probably not being able to hear it. Toads, frogs, and lizards are the flies' next worst enemies but these predators finish their prey at one gulp and the insects have no chance to make a sound before they are where feeling rather than hearing is likely to tell the captor whether or not it has swallowed a bee. Birds may be

deceived—I do not know—but, despite the fact that a large group of birds are called flycatchers, they are not relatively serious enemies of the Diptera and there are birds that have a fondness for bees—sting, warning sound, and all. Therefore, it seems to me that this shrill sound about which so much has been written has no significance. It is merely an incident to the extra vigorous working of the wing-muscles under the excitement of being captured.

There is a large and widely distributed group of grasshoppers the members of which, unlike those of other groups, have bright hind wings visible only in flight. The males of this group are much given to hovering over the females, displaying these wings and calling attention to the bright colors by a rattling sound made by striking the wings together. At least, that is the way it looks at first glance and it may be true. And so this has become a classic example of the theory of sexual selection. Years ago I myself wrote a perfectly orthodox paper on the "Ecology of Insect Sounds" and used these grasshoppers as the principal illustration. Since then I have spent many hours in the hot sun watching the lady in the case and I must say that, if human lovers received as little response to their serenades as do the courting grasshoppers, most of them would either give up music or remain bachelors. Furthermore, the theory of sexual selection requires that these females have so much better ears than ours that they are able to detect slight differences in either the tone or the intensity of a male's rattle. Of this there is not a single bit of real evidence and, in fact, most of the recent work on the audition of insects tends to the conclusion that, if they are not actually deaf, they certainly pay but little attention to sounds within our audible range. It seems quite possible that this courtship music has no significance other than an incidental hitting together of the wings as the male hovers to get the scent of a female hidden in the grass, for we know that insects have very keen olfactory powers but relatively poor vision.

What I have seen happen is that, when such a male comes back to earth and approaches the female, he nervously twitches his long hind legs up and down. This brings me to a second class of insect sounds, those made by friction rather than beating.

Most insect sounds are made in this way. Although the twitching legs of which I have just spoken caused no sound that I could hear, certain grasshoppers, belonging to a related group but not having bright hind wings, do make a sound audible to us when the hind legs rub against the body.

The most familiar example of insect sounds made by friction is the chirping of crickets. Now, only the males do this. Chirping is distinctly a secondary sexual character, the stock explanation of which is that it is a mating call developed by sexual selection. The adult life of a male cricket lasts a month or so and he chirps most of the time but he spends little of that time in mating. Why does he chirp when there is no female around? Possibly hoping that one will come; I do not know. When he has mated, his sexual life is done but he keeps on chirping to his dying day. I do not know why; possibly to pass the time. I do know this, however, and my knowledge is based on the breeding of literally thousands of crickets while I was using them in a study of heredity: a female cricket pays but little attention to a chirping male. She may wave her antennæ in

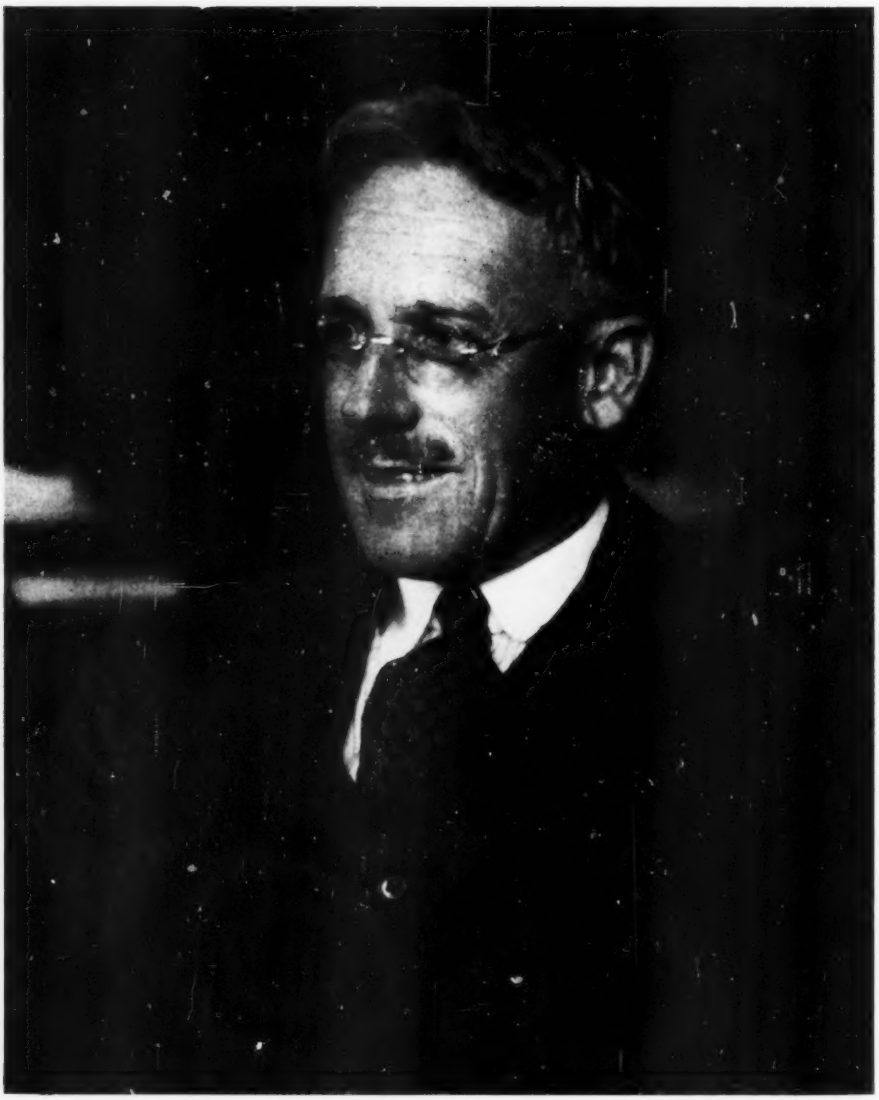
his direction but so will she when he is not chirping and so will she at a stick or a stone.

One of the most remarkable—shall I say—"adaptations" among insects for the production of sound by friction is possessed by the grub of a beetle. A pair of legs is grotesquely modified and the insect rubs them against a sort of a wash-board affair on its body. This has been as good as a cross-word puzzle for those who hunt for purpose in everything. The creature is immature and so is not looking for a mate. It lives concealed in rotten wood, so we have trouble in believing that it keeps on making the sound to fool unseen enemies that do not see it into believing that there is something dangerous, instead of a nice fat grub, in that piece of wood. One guess, soberly made, is that the sound is to notify brothers and sisters of its presence so that they will not eat too close to its preëmpted property.

When we can explain the purpose of a man's snoring or of the rattling of a Ford car, we may know why this beetle grub rasps. Having slept with a man that snored and having driven a Ford, I believe that the sounds in question are unintentional and quite incidental to the structure of the man and of the machine. May not the same be true of the beetle grub?

Physicists tell us that the intensity of a sound varies as the square of the number of vibrations per second (that is, the pitch) and also as the square of the amplitude of these vibrations. Now, insects are small, weak creatures, and the amplitude of any sound-waves made by them is therefore necessarily small. Consequently, an insect sound must be shrill or it will not be intense enough for man to hear it. We know that some insect sounds are so shrill that they are above the audible range of some humans. It is tempting to wonder if many insects do not make sounds too shrill for any of us to hear. The determination of this is a matter of biophysics and not easy. I spent most of one summer working with the co-operation of Doctor Thomas of the Westinghouse Research Department upon the problem, but we were not successful. Such sounds may or may not be made. We should know before our speculations concerning the sounds which we can hear but which certainly are not made for our ears have become so crystalized that we believe them to be established facts instead of more or less intelligent guesses. Furthermore, if insects in general do communicate with one another by means of sounds, the sounds employed are doubtless those above our audible range.

The significance of insect sounds is still an open subject and, while it is altogether probable that some of these sounds do have a biological significance, I firmly believe that many of them have none, being merely incidental to actions that are not intended to make a noise and to structures that have arisen for some totally different purpose or for no purpose at all.



RALPH WINFRED TOWER
1870-1926

For twenty-three years Curator of Books and Publications and of Physiology in the American Museum

Ralph Winfred Tower
1870-1926

By GEORGE H. SHERWOOD
Acting Director, American Museum

ON the morning of January 26, that dread disease, pneumonia, struck down Ralph Winfred Tower in the very prime of his manhood. He was only in his fifty-sixth year and personal illness had been unknown to him. Thus his death, coming after a sickness of barely seven days, has left his friends and associates stunned by their unexpected loss. Through Doctor Tower's death there is a real void, not merely in the Library staff, not merely in the Scientific Staff, but in the personnel of the Museum as a whole. Doctor Tower was so modest and unassuming that we are only just beginning to realize what an important and necessary share he bore in the life of the Museum and in scientific activities outside.

Ralph Winfred Tower was born at Amherst, Massachusetts, May 24, 1870, the son of the Reverend Doctor Francis Emory Tower and Ella Sophia (Shepardson) Tower. His father was a high-minded, forceful man, a thorough student, and the valedictorian of his class at Amherst. From his father Doctor Tower inherited his studious nature and the great love of books which is so outstanding in his life work. His mother was one of the most gentle and one of the sweetest characters that it has ever been my privilege to know. From her Doctor Tower inherited his genial smiling philosophy and his great love of music.

Doctor Tower's earliest education was obtained in the public schools of Allston, a suburb of Boston, and there is some evidence that his taste for study was not developed in those early years. The back lots of Allston claimed him whenever he could escape from parental discipline. On these same back lots was laid the foundation of his strong constitution and his athletic ability, which won for him the coveted B of Brown University as a pitcher on the baseball team. Even in these early days, however, he appreciated the value of an education. One day his mother heard a caller who was chatting with him say, "Do you like to go to school, little boy?" and the youngster replied, "No, not very well, but I'd rather go to school than grow up and be a dunce."

Doctor Tower prepared for college in the high schools of Brattleboro, Vermont, and Bristol, Connecticut, and from the latter he was graduated in 1888. His high-school studies gave him some difficulty, especially algebra. The principal in exasperation at his slowness in grasping the problem said before the whole class, "Well, you young divine, you will be out preaching before you get that example done." Young Tower was horribly mortified and told his mother that he wasn't going to have anything like that said to him again. He not only passed his algebra but received nearly the highest mark in his class.

In the fall of 1888, Tower entered Colby College at Waterville, Maine, where he remained two years. Then, finding that he could not get the courses in science which he desired, he trans-

ferred to Brown University, particularly that he might study under Alpheus S. Packard, a student of the great Agassiz, and the great entomologist of his day. He was graduated from Brown in 1892 and was immediately appointed instructor in biology. In addition to teaching he carried on graduate work and took his Master's Degree in June, 1893. His biological training gave him a keen interest in physiology and physiological chemistry. He determined to make this subject his specialty and to spend a year of study in Germany.

In August, 1893, he married Bessie Belle West and with his young bride took up his residence in Leipzic, where he could work under the great physiologist, Prof. Max von Frey, of the University of Leipzic.

Upon Tower's return from Germany in the summer of 1894, President E. Benjamin Andrews appointed him demonstrator of anatomy, and the following year asked him to develop a course in physiological chemistry as a part of the program for a strong biological department at Brown. Tower held the post of instructor in physiological chemistry from 1895–99, when he was promoted to the assistant professorship and later to the associate professorship in this subject. He held the latter position until 1903, when he resigned to accept the dual post of curator of physiology and curator of books and publications in the American Museum of Natural History, which he filled for twenty-three years.

Tower's greatest service to the Museum and the lasting monument to his memory is the Library, one of the largest and finest devoted to natural sciences in the world, which has been developed by him from an insignificant collection of books to the well balanced, efficient research instrument of today. The question is frequently asked, How did Doctor Tower, a specialist in physiology, happen to take up the development of the Library as his life work? The story dates back to the reorganization of the biological department of Brown University. President Andrews appreciated the necessity of having an up-to-date biological department in order to keep pace with modern thought and modern sciences. He appointed Dr. Herman C. Bumpus the head of this department, and he in turn gathered around him Dr. A. D. Mead, Frederick H. Gorham, and Ralph W. Tower. This nucleus of young biologists laid the foundation of the present strong department at Brown. A library was one of the essentials of such a department. Because of Doctor Tower's acquaintance with scientific literature, combined with his innate love of books, he was entrusted with the problem of building up the department library, in addition to his regular duties as instructor in physiological chemistry. Funds were very limited and a most judicious selection of books had to be made. About this time, 1898–99, the first of the Field Concilium Bibliographicum cards came out and the biological department subscribed for a set. Doctor Tower mastered the intricacies of this system and put the department library on a Field basis. Here, then, was a man, trained in science and not bound by the tradition of any library school, who could apply his training in a common sense way to the development of a special library for workers in natural science.

It was then that President Jesup invited Doctor Tower to come to the Museum as curator of books and publications, and to devote himself to

building up an adequate library for the Museum. Doctor Tower applied himself to this new field with singleness of purpose and achieved marked success. While our small Library of that time did contain some rare and valuable works, they were inaccessible, and staff members or others were discouraged from using them. All of this was changed immediately. Doctor Tower organized the existing material, installed the Field Concilium Classification System, and then by a most careful selection of books and through exchanges added to the supply until today the Library contains more than 100,000 volumes. In the meantime through his conviction that the efficiency of a library is determined by its practical use, he encouraged inter-library loans to assist research workers in all parts of the country, and otherwise administered the library in a liberal spirit of coöperation. It is this spirit of helpfulness that is one of the greatest assets of our Library today.

Largely through his influence and because of confidence in him, the Library of the New York Academy of Sciences was deposited in the Museum in 1903. The Academy Library was rich in serial publications of learned societies. Doctor Tower did not try to duplicate the Academy Library but rather used it to supplement the Museum Library. Thus, during the last twenty-three years, although the two libraries were kept distinct on paper, they were physically treated as a unit. This plan worked advantageously for both institutions, but at last a point was reached where it was imperative that the Academy Library should definitely become a part of the Museum Library in order to safeguard for all time this essential unity of operation. Doctor Tower realized the importance of merging these two rich collections that supplemented one another so admirably and one of his last official acts was to carry out the details of the plan. The purchase was made possible through the generosity of Mr. Ogden Mills, a Trustee of the Museum and a devoted patron of the Library.

Although books and publications became Doctor Tower's life work, he never lost interest in his first love, physiology. The Library, however, so absorbed his attention that he had little time to devote to his physiological researches. Nevertheless, through the literature and his contact with medical men and other scientists he kept himself informed of the general progress in this science.

Between 1895 and 1908, Doctor Tower published eleven scientific treatises. The most important of these was his thesis on "The Gas in the Swim-Bladder of Fishes," representing the results of his investigations in the biological laboratory of the U. S. Fish Commission at Woods Hole, Massachusetts, which was accepted as his thesis for the degree of Ph.D., conferred upon him by Brown University. The function of the swim-bladder in fishes and the production of sound by fishes continued to interest him, and his last paper on this subject was published in the Annals of the New York Academy of Sciences in 1908, under the title "The Production of Sound in the Drumfishes, the Sea-Robin and the Toadfish."

It is quite natural to think of Doctor Tower's service to the Museum in the terms of the Library, because this was his greatest achievement, but his participation in other Museum activities was of nearly equal importance. This is particularly true of his service on the Pension Board and on various com-

mittees. He was a member of the Pension Board from its creation, and no one could have taken a greater interest in the individual problems of the employees than he. In the councils of the Pension Board and in informal conferences on the welfare of employees, Doctor Tower's opinion commanded the respect of his colleagues, and through his sympathetic understanding of the condition of the employees he gained their loyalty and devotion. Doctor Tower's strong sense of justice, his belief in the equality of each member of the Pension System, his firmness in standing for what he believed was right, and his practical common sense in analyzing difficult problems have contributed much to the maintenance of the integrity of our Pension System, of which we are justly proud.

Closely associated with official pension and welfare work was his service to our employees as general physical adviser and in the giving of first aid. His efficiency and unostentatious ministrations in these emergencies inspired all with confidence. His bright and cheery smile lifted many an employee out of despondency and started him on the road to recovery. A characteristic trait which endeared him to the entire personnel of the Museum was his willingness to give freely of his knowledge and of his time to the humblest of our employees as well as to his most intimate friends. Considered from the standpoint of this activity alone, his death has caused a sad loss.

For about fifteen years Doctor Tower was secretary of the publication committee of the Museum, and in this office his knowledge and advice were of the utmost value. In 1922 he was placed in charge of the printing shop, and through his executive ability and technical knowledge of publication, as well as his conservative recommendations, a printing plant of high efficiency and low cost was developed. Doctor Tower applied his customary thoroughness to the business of printing and handled with equal tact both the labor problems within and the pressing departmental claims for production.

In addition to his manifold duties as a Museum officer, Doctor Tower gave of himself most generously to other activities which he felt would advance science or education. This is especially true of his long service in connection with the New York Academy of Sciences. For twenty-three years he was its librarian, and for nine years its editor.

His most conspicuous contribution to the New York Academy was his nine years of service as its recording secretary, which *per se* made him its principal executive officer. His wide acquaintance with scientific matters, his appreciation of the scientist's view point, and his administrative ability fitted him to be an ideal representative of this distinguished society, while his ability, his good judgment, his clear perspective, and sound advice made him an invaluable adjunct to its Council, and won for him the high respect and honor of all his fellow members of the Academy and its affiliated societies.

At a Memorial service held in the reading room of the Library on Wednesday afternoon, January 27, the day following Doctor Tower's death, President Osborn and other Museum officers paid an eloquent tribute to Doctor Tower's life and work. At this time also Professor Henry E. Crampton, president of the New York Academy of Sciences, so forcefully depicted Doctor Tower's dominant qualities of character and his genius that I have

requested permission to incorporate his remarks in this article.

On this occasion, it is my privilege to say a few words about our colleague who has passed away, as an officer of the New York Academy of Sciences; but this privilege is assumed with the greatest difficulty, for I knew him not only as an associate in the Academy but also as a friend during a long period of time.

I like to recall Ralph Tower as I first knew him nearly thirty-three years ago when he came to the Biological Laboratory at Woods Hole, then in its earlier and more primitive days. He was one of a notable group of young workers in the full flush of enthusiasm for their studies in zoölogy. Among others, from Brown University came Gorham, Straus, and later Sherwood, and from Williams there were Peabody, Conant, and Harrington,—two of whom were soon to sacrifice their lives in the quest for new knowledge. And in that group, Ralph Tower was a central figure, always earnest, reliable, and even-tempered, and a man whose winning personal qualities made a real friend of everyone who came to know him.

The years passed, and he came to the American Museum to undertake the exacting duties which he discharged for so long a time, bringing to his new occupations all of the sterling qualities he had possessed at the outset and all that he had gained through his work in science. Later he entered the service of the New York Academy of Sciences, and assumed one office after another—librarian, editor, and recording secretary—until the work of this venerable organization came to be wholly under his direction.

Among the many fine attributes of character and charm that he possessed, to me his outstanding personal quality was the sincere honesty of his every thought and word and action. From this arose the sound judgment upon which all of his associates relied; because of this, also, he was intolerant of sham and pretense, as he was equally ready to appreciate real merit where he found it. And the standards by which he judged others were no more exacting than those which he set for his own thought and conduct.

The Academy has lost a devoted and faithful officer, while every one of us has lost a friend. The ranks close up and we go forward, as we must. Yet in the future, we who knew him, almost will feel the presence of our friend; when problems arise, and we shall ask "What would Tower think about this?" almost we shall hear the calm words of advice and judgment, as we did in the past.

In conclusion, may I quote a few words which to my mind express so adequately the spirit of such a man as Ralph Tower and of all like him who engage in the sincere search for knowledge and truth. They are the words of a great poet, Whittier, and they voice the spirit of a great naturalist, Agassiz, who with his students had lately begun the work at the unique seaside laboratory on the island of Penikese:

> We have come in search of Truth,
> Trying, with uncertain key,
> Door by door of mystery.
> We are reaching, through His laws,
> To the garment-hem of Cause,
> As, with fingers of the blind,
> We are groping here to find
> What the hieroglyphics mean
> Of the Unseen in the Seen;
> What the thought that underlies
> Nature's masking and disguise;
> What it is that lies beneath
> Blight and bloom and birth and death.

Although Museum and Academy interests absorbed most of Doctor Tower's energy, he nevertheless made his contribution to civic affairs, among which were his fifteen years of service on the Library Board of his home city, New Rochelle, first as Treasurer for nine years and then as President of the Board for the last six years. It was during his term of office that the new library building was erected and he had much to do with bringing it to its present efficiency.

One of my most cherished possessions is my long friendship with Doctor Tower, which extends over a continuous period of nearly thirty years. We were *comrades* in all that that word can mean. We worked together, we played together, we shared our sorrows and our joys. My comrade has gone but I feel that his spirit is still with us and will inspireus to better work. I know that this is a better world because he lived in it and it is with real feeling that I say,

> He was a man, take him for all in all,
> I shall not look upon his like again.

Jugatæ, the entomological club at Cornell University

NOTES

ENTOMOLOGY IN THE UNITED STATES

No other group of animals engages the professional work of so many students as does Hexapoda, the insects; and, with the possible exception of birds, no other group fascinates so many amateurs.

It is indeed a backward state that does not have at least one professional entomologist in its official family and some states have well-equipped departments devoted to this study. Then, there is the Bureau of Entomology of the U. S. Department of Agriculture. The Bureau maintains headquarters in Washington but its activities are widespread. For example, in coöperation with New Jersey and Pennsylvania, it maintains at Riverton, New Jersey, a Japanese Beetle Laboratory that employed about two hundred men last summer.

There is an American Association of Economic Entomologists that since 1908 has published the *Journal of Economic Entomology*. The *Annals of the Entomological Society of America* is the official organ of another national society, in this case devoted to pure rather than to applied entomology. A number of societies, primarily amateur and local in character, publish journals of great scientific importance and world-wide circulation. One of these, the New York Entomological Society, has for more than thirty years been closely associated with the American Museum.

Not so long ago it was possible for a young man or woman to become a professional entomologist by the apprentice route, just as they could become lawyers by "reading" in an office, but now entomology is a graduate study in our larger universities. The accompanying illustration is a picture of Jugatæ, an entomological club made up of students and teachers in Cornell. Seated in the center of the front row are Professor and Mrs. Comstock, than whom no one in America has done more to stimulate interest in and diffuse knowledge about insects, spiders, and nature in general. The second person at Professor Comstock's right is Professor Needham, America's leading authority on aquatic insects.

It is with a great deal of pleasure, albeit tinged somewhat with envy, that the American Museum presents to its readers a picture of some of the workers in the best-manned department of entomology of any museum—that of the U. S. National Museum. As a matter of organization, most of these workers are connected with the U. S. Department of Agriculture; but, as a matter of practice, they are on the staff of the Museum.

Number 11 in the picture is Dr. L. O. Howard, honorary curator in the Museum, chief of the federal Bureau of Entomology, and, incidentally, the author of one of the articles in this issue of Natural History. Number 9, Dr. E. A. Schwarz, has long been an outstanding authority on beetles and is honorary custodian of Coleoptera. Other coleopterists are Dr. A. G. Böving (4), Mr. W. S. Fisher (13), and Mr. H. S. Barber (14). Dr. H. G. Dyar (8), honorary custodian of Lepidoptera, is an independent worker who is donating his services to the Museum. Dr. William Schaus (3) is also an authority on butterflies and moths. Unfortunately, the

picture does not show two other lepidopterists of the staff, Messrs. Heinrich and Busck. Neither does it show Doctor Aldrich, who is a well-known specialist on flies and has charge of the Museum side of the insect work. Other dipterologists are Mr. C. T. Greene (2), and Mr. R. C. Shannon (12). Mr. S. A. Rohwer (10) is in charge of the taxonomic investigations of the Bureau of Entomology and hono-

Some of the entomological workers attached to the U. S. National Museum

rary custodian of Hymenoptera in the National Museum. Other students of this order, which includes ants, bees, and wasps, are Mr. A. B. Gahan (1), Dr. W. M. Mann (6), Mr. R. A. Cushman (15), and Mr. Weld (not shown). Mr. A. N. Caudell (5) is concerned with grasshoppers and their relatives; and Dr. H. E. Ewing (7) with mites and various insect parasites of warm-blooded animals. The others shown are a few of the National Museum's staff of entomological preparators, clerks, and artists. The American Museum most warmly congratulates its sister institution on having such a large number of helpers and on the work that they are donig.

AN ANCIENT RING OF ENTOMOLOGICAL BEARING

Professor E. B. Poulton, in a personal letter to President Henry Fairfield Osborn, called attention to an ancient ring that has an entomological bearing and was reported upon at a meeting of the Entomological Society of London last year. It was discovered by Sir Arthur Evans in Greece and apparently dates from about 1500 B.C., Butterflies are used to symbolize the soul and the engraver evidently had some knowledge of entomology, for he not only depicts the chrysalis from which an adult butterfly emerges, but he has carved a recognizable Pierine butterfly and associated it with the right sort of chrysalis. This antedates Aristotle by more than a thousand years Incidentally, the letter indicates the breadth of Professor Poulton's keen interest in entomology, an interest that many have come to associate largely with the theory of mimicry because he has done so much in defense of that theory.

HONORARY FELLOWS

On November 9, 1925, at a board meeting of the Trustees of the American Museum, the following resolution was unanimously adopted:

Resolved, That the Trustees desire to record their appreciation of the splendid service rendered by Mr. Lincoln Ellsworth in the recent Arctic flight of Captain Roald Amundsen, in which his courage, endurance, and good judgment were evidenced, and in recognition of his manly qualities and his contribution to polar exploration take pleasure in hereby electing him an *Honorary Fellow* of the Ameri-

can Museum of Natural History—the highest honor in their power to bestow.

On March 17, 1926, the following resolution was unanimously adopted:

Resolved, That the Trustees desire to record their appreciation of the contributions that Mr. Howard Russell Butler has made to the popularization of astronomy through his unique paintings of solar eclipses and other astronomical paintings, and, in recognition of his attainments in this field of science, take pleasure in hereby electing him an *Honorary Fellow* of the American Museum of Natural History.

NEW MEMBERS

Since the last issue of NATURAL HISTORY, the following persons have been elected members of the American Museum, making the total membership 8781.

Associate Founders: MESSRS. FREDERICK F. BREWSTER, AND D. B. WENTZ.

Associate Benefactors: DR. WALTER B. JAMES, MESSRS. WILLIAM DOUGLAS BURDEN, JOHN A. ROEBLING, AND HENRY W. SAGE.

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PAST RACES OF MAN

MAY-JUNE

The year 1926 opened with a number of **Natural History** devoted to present-day man. The forthcoming issue will tell of recent discoveries regarding the vanished races of mankind —their environment, their industrial and artistic works, and their skeletal remains—and also concerning fossil primates.

The Abbé Henri Breuil—widely acknowledged as one of the two foremost authorities on European archæology—gives a delightful account of how, in company with Capitan and Peyrony, he discovered the tortuous cavern of Les Combarelles with its spirited portrayals of animals and weird anthropomorphic designs. Père Teilhard de Chardin, professor of geology in the Institut Catholique de Paris, describes how, in company with his friend, Père Licent, he found implements of Palæolithic man together with bones of the animals he hunted, buried deep beneath the loess of China and Mongolia. Nels C. Nelson, of the Third Asiatic Expedition and curator of archæology in the American Museum, tells how he found implements of chipped stone, broken pottery, and animal bones dating back to the Stone Age, in the wastes of the Gobi Desert. Othenio Abel, the distinguished professor of palæobiology in the University of Vienna, during the excavation of the Drachenhöhle (Dragon's Cave) near Mixnitz, Austria, in 1920–1923, unearthed Palæolithic artefacts and remains of cave bear under most extraordinary conditions, which he interprets as indicating that cave bears were ambushed and killed by Palæolithic man in this very cave.

Pliny E. Goddard, curator of ethnology in the American Museum, sums up cultural and linguistic evidence which seems to indicate a much greater antiquity of man in America than has hitherto been admitted. In this connection Frederic B. Loomis, professor of geology at Amherst, gives the results of a joint expedition of Amherst College and the Smithsonian Institution to investigate sites reported in Florida, and shows that at four different places there were either human bones or human artefacts associated with bones of mammoth and mastodon, implying an age of some twenty thousand years.

Henry Fairfield Osborn needs no introduction to readers interested in men of the Old Stone Age. He discusses evidence indicating why Central Asia may prove to have been the cradle of humanity. Mr. Harry C. Raven, widely known as an intrepid explorer, and about to leave shortly on a collecting expedition to the Arctic, takes time to report on the unique sculptures in rough-hewn stone which he photographed in the heart of Celebes. These offer a knotty problem to the archæologists, for though one or two show remote resemblances to the strange figures of Easter Island, yet on the whole they seem to be quite unlike any types known hitherto. Frederic A. Lucas, veteran naturalist, explorer, and sailor (from the age of ten!), gives a whimsical account of the grotesque misapprehensions of earlier days regarding fossil animal remains belonging to the Age of Man, which mightily puzzled the enterprising souls who tried to "restore" them. He also adds to our collection of Americana a convincing tribute to "Thomas Jefferson—Palæontologist."

The remaining articles constitute a symposium on fossil man compared with the anthropoids. Raymond A. Dart, professor of anatomy in the University of the Witwatersrand, South Africa, presents a splendidly illustrated account of the discovery of the Taungs skull and brain cast, and rehearses the evidence which leads him to class it as a "missing link," or man-ape. Dudley J. Morton of the Department of Surgery, Yale, contributes a most illuminating analysis of the skeletal structure of Neanderthal man compared with modern man and with the anthropoids. G. Elliot Smith, world-famed anatomist and archæologist, outlines the results of his searching investigations regarding the brain structure of fossil man. William K. Gregory and Milo Hellman—the latter research associate in anthropology in the American Museum—disclose the conclusions reached through their joint research concerning the crown patterns of human teeth, fossil and recent.

Finally J. H. McGregor, professor of zoölogy at Columbia University, shows the methods he employs in making his restorations of fossil man. The famous English painter, Sir Frederick Leighton, used to draw his preliminary sketches of human figures in the nude in order to secure perfect truth of detail, afterward adding the drapery. But Professor McGregor goes further, he models first the skeletal structure of his restorations, then the musculature, and finally the outside layer of flesh and skin.